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A COMPARISON OF STATISTICS ANXIETY AND MATHEMATICS ANXIETY AMONG GRADUATE STUDENTS IN THE SOCIAL SCIENCES

BY

CAROLYN WENTZEL ©

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfilment of the requirement for the degree of DOCTOR OF PHILOSOPHY

DEPARTMENT OF EDUCATIONAL PSYCHOLOGY

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The undersigned certify that they have read, and recommend to the faculty of Graduate Studies and Research for acceptance, a thesis entitled A COMPARISON OF STATISTICS ANXIETY AND MATHEMATICS ANXIETY AMONG GRADUATE STUDENTS IN THE SOCIAL SCIENCES in partial fulfilment of the requirements for the degree of DOCTOR OF PHILOSOPHY.

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ABSTRACT

The purpose of this study was to compare statistics anxiety and mathematics anxiety among graduate students in the Social Sciences enrolled in an introductory statistics course. The mathematics anxiety scale used by Plake and Parker (1982) was adopted in the present study. The wording of this scale was maintained to assess mathematics anxiety and then adapted as a scale to assess statistics anxiety. Two response formats were considered: a 5-point Likert scale and a visual analogue scale.

Working with 92 students in a beginning graduate statistics course for the Social Sciences, response formats did not differ. Further, both statistics and mathematics anxiety were found to be comprised of two correlated factors: one related to course content and the other to evaluation. The mean scores for the two course content and evaluation scales across a four week interval did not change for both subjects; test-retest reliabilities were high, ranging from .67 to .80. Correlational analysis revealed that course content anxiety appears to be situational (i.e., dependent upon subject) or state in nature; evaluation anxiety appears to be more of a trait (Speilberger, 1983). Implications for practice and for future research are provided.

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CHAPTER I: INTRODUCTION

The existence of statistics anxiety among some university students enrolled in undergraduate and graduate level introductory statistics courses would appear to be indisputable; an observer need only listen to comments made by students prior to and during a required course in statistics. Such courses frequently elicit feelings of apprehension and dread in students (Schau, Stevens, Dauphinee, & Del Vecchio, 1995; Wise, 1985; Zeidner, 1991). Zeidner (1991) described statistics anxiety as a particular type of performance anxiety identified by "...extensive worry, intrusive thoughts, mental disorganization, tension, and physiological arousal" (p.319).

A basic understanding of statistical concepts is inherent to many areas of study. Consequently, students with diverse backgrounds, interests, and ambitions are required to take an introductory course in statistics as a necessary component of their program. Many students experience severe difficulties with courses of this type (Bradstreet, 1996; Feinberg & Halperin, 1978). In extreme circumstances statistics may be the most demanding and anxiety evoking course encountered by students throughout their program (Onwuegbuzie & Seaman, 1995; Zeidner, 1991).

These feelings of anxiety may result in avoidance of statistics courses (Zeidner, 1991), postponement of the course for as long as possible (Gal & Ginsburg, 1994, Roberts & Bilderback, 1980), and affect the comfort level of students, as well as their instructors, when taking statistics courses (Schau, Dauphinee, & Del Vecchio, 1993). Feinberg and Halperin (1978) and Zeidner (1991) recognized that statistics anxiety may serve as a detriment to performance in statistics and, consequently, have a negative impact on a variety of academic situations. This type of anxiety may also result in forced changes in academic programs and career choices (Feinberg & Halperin, 1978).

Bradstreet (1996) reported that statistics anxiety is likely more intense for graduate students than for undergraduate students due to the realization that data analysis will be an important component of the research they must conduct. Additionally, the anxiety associated with courses in statistics may be further magnified among graduate students in education as well as other social science disciplines that require little or no prior statistics or mathematics courses (Onwuegbuzie & Seaman, 1995; Zeidner, 1991).

Although statistics anxiety has been clearly identified as a persistent difficulty for many university students, very little research is evident in which this issue is explicitly addressed. Most of the previous research has examined statistics anxiety indirectly by means of instruments designed to assess statistics test anxiety (Benson, 1989; Benson & Bandalos, 1989), attitudes toward statistics (Fenster, 1992; Gal & Ginsburg, 1994; Schau, Dauphinee, & Del Vecchio, 1995), or mathematics anxiety (Pretorius & Norman, 1992).

Undoubtedly, both statistics test anxiety and attitudes toward statistics are components of general statistics anxiety. However, these constructs appear to provide only a partial depiction of this construct. The use of a mathematics anxiety instrument to assess statistics anxiety may provide some potentially useful insights into statistics anxiety, although this practice implies that the two constructs are the same. While it would appear reasonable to postulate that a relationship exists between mathematics anxiety and statistics anxiety, there is no research which demonstrates the specific degree to which this is a correct assumption.

Unlike statistics anxiety, extensive research has been devoted toward the assessment of mathematics anxiety during the past 25 years (e.g. Ferguson, 1986; Hembree, 1990; Richardson & Suinn, 1972; Rounds & Hendel, 1980; Tobias, 1978). As will be discussed in the following chapter, some studies have suggested that mathematics anxiety and statistics anxiety are essentially the same constructs; however very little is known regarding the specific similarities and differences between the two constructs.

Bradstreet (1996) suggested that statistical anxiety may develop from mathematics anxiety, particularly for undergraduate and graduate students who have minimal mathematics backgrounds. He proposed that some of these students perceive a high level of mathematics knowledge as necessary for success in statistics courses; the association between statistics and mathematics is therefore unavoidable and intimidating for these students.

Bradstreet (1996) pointed out that statistics goes beyond mathematics and the manipulation of numbers in mathematical problems because statistics "includes the gathering and use of data, and the application of the results of statistical analyses to everyday life in the form of concrete decisions" (p.70). Consequently, if statistics is viewed as a subject of more far-reaching applications than mathematics, then it may follow that statistics anxiety is a broader concept than mathematics anxiety (Bradstreet, 1996; Cruise, Cash, & Bolton, 1985).

The association between general anxiety and mathematics anxiety has received less attention. A limited amount of research has reported that a moderate, positive relationship exists between state and trait anxiety and mathematics anxiety (e.g., Betz, 1978; Hembree, 1990; Schwarzer, Seipp, & Schwarzer, 1989; Zoller & Ben-Chaim, 1988). However, the association between state and trait anxiety and statistics anxiety is essentially unidentified. Although statistics anxiety is recognized as a serious obstacle for many students, very little is known about its relationship to general anxiety and mathematics anxiety.

A further issue in the assessment of statistics anxiety and mathematics anxiety relates to the type of response format employed. Research investigating mathematics anxiety has typically employed instruments that utilize a Likert scale (e.g., Fennema & Sherman, 1976; Richardson & Suinn, 1972). Likert scales are one of the most common item formats used to measure opinions, beliefs, and attitudes (DeVellis, 1991); however the effect of different response formats has not been examined. Specifically, with regard to the measurement of statistics and mathematics anxiety, it is not known whether different types of response formats would produce different outcomes.

Purpose of Present Study

There is paucity of research in which the nature of statistics anxiety and mathematics anxiety has been compared and the relationship between them examined. Furthermore, the influence of response format when assessing statistics anxiety and mathematics anxiety has not been researched. The purpose of this study was to investigate the converging and diverging components of these two types of anxiety, using two different response formats. More specifically, the following questions were addressed:

1. Do different measurement strategies result in different levels of statistics anxiety and mathematics anxiety?
2. What, if any, differences exist between the cognitive and affective elements which comprise statistics anxiety and those which constitute mathematics anxiety?
3. Does level of statistics anxiety and mathematics anxiety change over time?
4. What are the relationships between state-trait anxiety, statistics anxiety, and mathematics anxiety?
5. Do the predictors of statistics anxiety and the predictors of mathematics anxiety differ?
6. What are the predictors of achievement in an introductory statistics course?

Definition of Terms

For the purposes of this study, the following definitions were adopted.

Anxiety - anticipation, current feelings, or recall of a personally relevant, real or implied, insecurity (Rost & Schermer, 1989).

Mathematics - the systematic treatment of magnitude, relationships among figures and forms, and relations among quantities expressed symbolically (Stein, 1988).

Mathematics Anxiety - extensive worry, intrusive thoughts, mental disorganization, tension, and physiological arousal that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations (Richardson & Suinn, 1972).

Statistics - the collection, organization, and interpretation of numerical data for the purposes of: (a) summarization, and (b) drawing conclusions about populations based on taking samples from that population (Gibson, 1994).

Statistics Anxiety - extensive worry, intrusive thoughts, mental disorganization, tension, and physiological arousal that interfere with the ability to cope with statistics content, problems, instructional situations, or evaluative contexts (Zeidner, 1991).

Trait Anxiety - predisposition toward anxiety-proneness; the tendency to perceive stressful situations as dangerous or threatening (Spielberger, 1983).

State Anxiety - subjective feelings of tension, apprehension, nervousness, and worry (Spielberger, 1983).

Delimitations of the Study

The delimiting factor in this study was the diversity of academic backgrounds and exposure to statistics of the students who participated in this study. Twenty-nine percent of the research participants had not previously taken a statistics course, 60% had taken an undergraduate course, and 11% had taken a statistics course at the graduate level. Furthermore, the majority of these students were taking the current introductory statistics course either because it was a requisite of their program or a prerequisite to entering a graduate program.

A further consideration was that participation was voluntary and not all students in the classes included in this study chose to participate. Consequently, the results obtained from these individuals may not necessarily represent anxiety toward statistics by graduate students in general. For example, graduate students with a background in statistics at the undergraduate level and those who intend to specialize in areas such as applied statistics will likely experience negligible, if any, statistics anxiety. Therefore, caution should be exercised with regard to the external validity or generalization of the research findings. Furthermore, the results from this study should not be generalized to undergraduate students due to the divergent backgrounds and experiences of undergraduate and graduate students.

Organization of Thesis

Chapter II provides a review of the literature regarding views of general anxiety, and current research in mathematics anxiety and statistics anxiety. The method of the research as well as preliminary analyses and results are described in Chapter III. Chapter IV presents the analyses and results that address the question of whether different measurement strategies result in different levels of statistics and mathematics anxiety. The issues of differences between statistics anxiety and mathematics anxiety, changes over time in degree of statistics anxiety and mathematics anxiety, and the relationship between these constructs and state and trait anxiety are examined in Chapter V. Also investigated in this chapter are differences between the predictors of statistics anxiety and mathematics anxiety, and the predictors of achievement in an introductory statistics course. Chapter VI provides a summary of the research questions and method, a description of the findings and limitations of the study, the conclusions of the research, and lastly, implications for practice and future research.

CHAPTER II: REVIEW OF THE LITERATURE

Presented in this chapter is a review of the literature related to mathematics anxiety and statistics anxiety. Research that examines affective characteristics occasionally refers to anxiety and attitude interchangeably (e.g., Gal & Ginsburg, 1994; Roberts & Saxe, 1982). Anderson (1988) advocates that attitude differs from other affective characteristics in terms of target, direction, and intensity. He explains that the targets of attitude are typically concrete, social objects, the directional indicators are favourable and unfavourable, and the level of intensity is usually moderate (p. 422). Anxiety is differentiated from attitude in that the former signifies anticipation, current feelings, or recall of a personally relevant, real or implied, insecurity (Rost & Schermer, 1989). This study addressed mathematics and statistics anxiety.

The number of research studies in which mathematics anxiety has been examined greatly exceeds the number of studies in which statistics anxiety has been investigated. Additionally, much of the work in the area of statistics anxiety has focussed on statistics test anxiety. With regard to the assessment of statistics anxiety and mathematics anxiety, the Likert scale is the most commonly used response format.

The review of the literature is organized into four sections. First, general anxiety is discussed. Within this section a brief summary of the development of anxiety as a concept is offered to provide a general context in which to view mathematics and statistics anxiety. This is followed by a discussion of state and trait anxiety as set forth by Spielberger (1983). Test anxiety and the effect of anxiety on performance are then addressed. Second, the concept of mathematics anxiety is discussed. Attention is paid to the assessment and dimensionality of mathematics anxiety, and the effect of anxiety on mathematics performance. The third section of the literature review addresses the concept of statistics anxiety. Consideration is given to the assessment of general statistics anxiety and statistics test anxiety. The effect of anxiety on statistics performance is also examined. Finally, a comparison of the Likert and visual analogue response formats is discussed in the fourth section of the literature review.

Current Views of Anxiety

Fear and anxiety have been recognized and analysed as a part of the human experience since early historical times (May, 1977; Spielberger, 1972). For example, Spielberger (1972) cites evidence that the concept of fear was observed in ancient Egyptian hieroglyphics, and anxiety was presented as a basic condition of human existence in the writings of medieval philosophers. Interpretations of anxiety offered by seventeenth century philosophers such as Descartes, Spinoza, and Pascal have significantly influenced modern anxiety theory (May, 1977). The reader is referred to May (1977) for a comprehensive historical review of the literature on anxiety.

Rost and Schermer (1989) observed that anxiety is one of the most frequently discussed and researched concepts within the various fields of psychology. However, consensus has not been obtained among researchers with regard to the facets which constitute anxiety. Anxiety is generally defined as feelings of insecurity (Rost & Schermer, 1989), feelings of mingled dread and apprehension (Chaplin, 1985), or an unpleasant emotional state or condition (Spielberger, 1983). Lader (1975) states that anxiety is a combination of manifested behavioral characteristics that can be examined scientifically and emotions that cannot be directly observed. Based on this amalgamation of attributes, he describes anxiety as "a mood, a feeling, an emotional response, a symptom, a syndrome, or an illness with course, prognosis, etc." (p.6). Regardless of the definition, Lader notes that the common element to all descriptions of anxiety is its unpleasant nature, relation to the future, and resemblance to fear.

Some researchers (e.g., May, 1977; Schwarzer & Jerusalem, 1992) have commented on the relationship between anxiety and stress. Schwarzer and Jerusalem (1992) assert that some individuals are predisposed toward anxiety when coping with stressful situations. May (1977) states that:

> Anxiety is how the individual relates to stress, accepts it, interprets it [sic]. Stress is a halfway station on the way to anxiety. Anxiety is how we handle stress. (p.113)

Lazarus and Folkman's (1984) cognitive relational emotion theory defines stress as a confrontation whereby demands upon an individual exceed perceived available resources. According to this theory, Schwarzer and Jerusalem (1992) state that cognitive appraisals include primary and secondary appraisal processes. Primary appraisal refers to the personal investment an individual has in a particular situation. Secondary appraisals reflect primary appraisals and refer to available coping strategies for dealing with stress.

In primary appraisal, a situation may be perceived as irrelevant, "benign-positive", or stressful. Events which are viewed as stressful can be further evaluated as challenging, threatening, or involving harm or loss (Schwarzer and Jerusalem, 1992). The primary appraisal of challenge is viewed as an opportunity to prove oneself. In this case, the individual assesses the situation as pleasant and feels confident in his ability to meet the demands. An appraisal of threat develops when an individual senses danger and potential or future harm or loss. During threat appraisal future outcomes are viewed negatively; however the individual is still striving to control the situation. Lazarus and Folkman (1984) describe the harm/loss classification of appraisal as that point at which the individual has already experienced some form of damage, such as injury to themselves or others, loss of important objects, or loss of social standing or self-worth. In this situation the individual is likely to feel helpless and submissive.

Within Lazarus and Folkman's framework, secondary appraisal represents the resources an individual perceives to have available in order to cope with the stress. During this appraisal phase the individual assesses his or her ability, accessible social support, and other resources in an effort to adjust to the situation and regain harmony between oneself and the environment.

Beck's cognitive theory of anxiety and depression (Beck & Clark, as cited in Schwarzer & Jerusalem, 1992) parallels many of the assumptions of Lazarus and Folkman. Threat is viewed as the main cognitive component in anxiety, while loss is considered to be a comparable element in depression. According to Bandura (1988) threat may be seen as a relational attribute which demonstrates the conflict between an individual's perceived coping abilities and aspects of the environment which can be interpreted as potentially damaging.

The appraisal of stress is closely associated with one's perceived personal coping resources. Schwarzer and Jerusalem (1992) state that the potential to cope with stress can be considered as an individual's disposition/personality resources or "vulnerability factors" (p. 4). According to this view, a person with low dispositional control expectancies will be more vulnerable to distress during a stressful situation than someone with perceptions of high disposition competence. Corresponding to Schwarzer and Jerusalem's (1992) notion, anxiety can also be conceptualized as a personal vulnerability factor. The following provides an insightful profile into the likely amalgam of self-perceptions held by "anxious individuals":

> High anxious persons tend to be permanently worried, they have weak competence expectancies, they interpret physiological arousal as an indicator of anxiety, and regard achievement feedback as social evaluations of their personal value, and they feel more responsible for failure than for success. (Schwarzer & Jerusalem, 1992, p. 4)

Furthermore, anxiety influences perceptions of threat and loss which can be classified as distress experiences. Incidents of distress tend to be perceived more strongly by individuals identified as highly anxious. Low anxious individuals are more likely to appraise similar situations as challenges.

Within the framework of primary appraisals, Schwarzer and Jerusalem note that challenge, threat, and loss are not experienced in isolation of each other; they should be viewed as "inter-related cognitive-emotional states that exist simultaneously" (1992, p. 4). The three categories of primary appraisal vary in strength and intensity according to particular situations and an individual's perceived resources. Therefore, the experience of stress must be viewed as a series of dynamic, unfolding processes that signify a complex series of appraisal patterns. Furthermore, primary and secondary appraisals do not follow an invariant sequence; primary appraisal does not always occur first. The two component processes of appraisal depend on each other and frequently emerge simultaneously (Schwarzer & Jerusalem, 1992).

State and Trait Anxiety

Spielberger (1972) recognized that the term "anxiety" is frequently applied in an indiscriminant manner. Anxiety is commonly used to describe a transitory state or condition that varies in magnitude and fluctuates over time. Anxiety is also used to characterize a personality trait that refers to individual differences in predisposition toward anxiety states. Spielberger (1972) differentiated between anxiety as a transient state and anxiety as an essentially stable trait. He proposed two anxiety constructs: state anxiety and trait anxiety.

State anxiety is defined as an emotional condition that changes in intensity and duration, and is characterized by subjective feelings of apprehension, nervousness, and worry (Spielberger, 1972, 1983). Degree of state anxiety is believed to increase in situations that are perceived to be threatening to an individual. According to Spielberger (1972), trait anxiety is defined as the predisposition to perceive situations as threatening and the likelihood of responding to perceived threats with state anxiety reactions. Individuals who demonstrate a high level of trait anxiety tend to perceive a greater number of situations as threatening. Consequently, they respond with a higher degree of state anxiety.

Within Spielberger's framework, trait anxiety is viewed as an individual's propensity toward anxiety in general, while state anxiety refers to reactions within specific situations. "The stronger the anxiety trait, the more probable that the individual will experience more intense elevations in state anxiety in a threatening situation" (Spielberger, 1983, p. 1). Although the connection between trait and state anxiety is evident, the relationship is not clearly predictive. According to Spielberger (1983) whether individuals who differ in trait anxiety demonstrate comparable differences in state anxiety depends greatly on the degree to which each individual perceives a situation as psychologically dangerous or threatening. This assessment is based largely on a person's previous experience.

Schwarzer and Jerusalem describe anxiety as "a personal vulnerability factor" (1992, p. 4). They report that individuals identified as possessing high trait anxiety are more susceptible to state anxiety, threat appraisals, and perceptions of coping inadequacies when faced with situational demands (Schwarzer & Jerusalem, 1992). These individuals frequently exhibit a diminished sense of competency (Carver & Scheier, 1988) and feel greater responsibility for their failures than their successes (Dweck & Wortman, 1982). Individuals characterized as having low trait anxiety are more likely to interpret stressful situations as challenging (Folkman & Lazarus, 1985; Schwarzer & Jerusalem, 1992).

Test Anxiety

An abundance of research has addressed the issue of test anxiety. Hong and Lam (1992) observed that the prominence of research in this area is due in part to the prevalence of testing situations and the importance placed on test results. They note that thirty years ago Sarason made the comment, "We live in a test-conscious, test-giving culture in which the lives of people are in part determined by their test performance" (1959, p. 26 as cited in Hong & Lam, 1992). Hong and Lam acknowledged that this statement is still true today.

Much of the research in this area has considered test anxiety to represent an interference paradigm (Hembree, 1990). Therefore, the experience of test anxiety is considered to disrupt the recall of previously learned information, thus causing an abatement in performance. Test anxiety is defined by an amalgamation of an individual's reaction to a situation and the specific situation (Rost & Schermer, 1989). Prior to the research of Liebert and Morris in 1967, test anxiety was conceptualized as a one-dimensional factor (Rost & Schermer, 1992). Since then, two widely accepted theories of test anxiety as a multi-dimensional characteristic have been advanced by Spielberger, Gonzalez, Taylor, Anton, Algaze, Ross, and Westberry (1980) and Sarason (1984).

Spielberger et al. (1980) viewed test anxiety as a trait defined by a specific set of situations. They asserted that the construct was comprised of two components, worry and emotionality. Worry is defined as "cognitive concerns about the consequences of failure" and emotionality is described as "reactions of the autonomic nervous system that evoked by evaluative stress" (p. 1). Speilberger et al. (1980) claimed that individuals who demonstrated high test anxiety perceived evaluation situations as personally threatening.

Zimmer, Hocevar, Bachelor, and Meinke (1992) state that

Sarason's (1984) model of test anxiety is best viewed as an extension of the model proposed by Spielberger et al (1980). They make this claim because two of Spielberger's original dimensions are included in Sarason's model. Sarason (1984) proposed that test anxiety was comprised of four dimensions: worry, test-irrelevant thinking, tension, and bodily symptoms. The worry factor is very similar to Spielberger's, and the tension factor includes many of the same characteristics as Spielberger's emotionality dimension (Zimmer, Hocevar, Bachelor, & Meinke, 1992). Test-irrelevant thinking refers to incidents of distracting thoughts during test taking, while bodily symptoms refer to physiological manifestations, such as headaches or nausea, which occur during test taking.

Test taking situations are one of the most apparent conditions in which feelings of anxiety frequently intrude and interfere with individuals' efforts (Carver & Scheier, 1989). Consequently, research in the area of test anxiety will likely continue to receive considerable attention.

The Effect of Anxiety on Performance

Considerable attention has been focused on the effect of anxiety upon performance. As pointed out by Schwarzer, Seipp, and Schwarzer (1989), although the relationship between anxiety and performance has been examined over a period of many years, a conclusive explanation still does not exist as to the typical effect size of this association. They noted that performance anxiety can be exhibited as general anxiety, test anxiety, social anxiety, or a domain-specific response such as anxiety toward a particular course like mathematics or activities such as sports.

The relationship between anxiety and performance may be positive and, therefore, serve as a facilitating factor, or negative with a consequential deleterious effect on performance (Schwarzer, Seipp, & Schwarzer, 1989). When faced with challenging situations, some individuals claim that they can "feel" a surge of adrenaline. This sensation tends to be viewed as a facilitating factor when coping with a situation. At other times perceptions of anxiety may have a paralysing effect on individuals, thereby serving as a debilitating factor.

With regard to the association between anxiety and academic performance, Benson (1989) claimed that this relationship is especially salient for courses involving quantitative concepts. Richardson and Suinn (1972) found that university students often reported high levels of test anxiety only when taking quantitative courses.

Schwarzer and Jerusalem (1992) observed that the anxiety-performance relationship is affected by the point in time at which measures are taken. They reported a small increase in the magnitude of the relationship between anxiety and performance when anxiety was measured after the achievement situation, rather than prior to the situation. In the case of academic performance, Seipp (as cited in Schwarzer & Jerusalem, 1992) reported average correlations of -.21 between anxiety and performance when measured prior to an academic achievement situation, compared to -.28 following the event. Information regarding the size and characteristics of the sample used in this study was not reported. Seipp (as cited in Schwarzer & Jerusalem, 1992) concluded that point in time is a moderator of the anxiety-performance relationship.

Regarding the association between anxiety and academic performance, Schwarzer and Jerusalem (1992) suggest several possible interpretations:

> (a) before the achievement situation all subjects anticipate ego-threat which may raise anxiety levels beyond normal levels, and thus reduce the anxiety variation (ceiling effect) which in turn lowers the correlation with subsequent performance scores;
> (b) when anxiety is assessed in an ambiguous moment immediately after task completion, but before a

> feedback is communicated, some subjects may be afraid of a failure feedback, while others feel already relieved because the demands have been met, leading to high anxiety variation;
>
> (c) in an ambiguous stress situation, state anxiety is more closely related to behaviour; therefore, the frequent use of state measures after task completion may be partly due to the timing effect, but also if trait measures are applied in such a situation, part of its variance can be attributed to the heightened state levels;
>
> (d) after failure feedback, some subjects may intentionally report more anxiety in order to make the impression that their arousal has been the cause of their failure, and not their incompetence; this is a strategic employment of anxiety expression as part of one's self-presentation. (p.15-16)

Schwarzer and Jerusalem (1992) further proposed that characteristics of the context within which achievement occurs should be considered when examining the relationship between anxiety and performance. They referred to classrooms as social settings where "unique student-teacher interactions take place" (p. 16). Therefore, characteristics such as teaching style, emphasis on achievement, and self-efficacy of students (Benson, 1989; Cooper & Robinson, 1991) may serve as moderating factors of the academic anxiety-performance relationship.

Schwarzer and Jerusalem (1992) recommended that future research in the area of anxiety should be causal in nature, in order to clearly understand factors such as the timing effect and the context effect. Future research should also be contextual because it is important to "explore the experience of anxiety in natural life settings and to identify the subjective meaning which the individual assigns to the unique properties of stressful encounters" (Schwarzer & Jerusalem, 1992, p. 17).

Mathematics Anxiety

Mathematics Anxiety as a Construct

During the early 1970s mathematics anxiety was studied using the theoretical framework developed for the investigation of test anxiety (Hembree, 1990). According to Hembree (1990), the popular belief was these two anxieties were similar, though not identical, constructs. Therefore, the methods, procedures, and treatments utilized for test anxiety could also be applied to mathematics anxiety. For example, Richardson and Woolfolk (1980) stated that mathematics anxiety can be considered a form of test anxiety in that solving a mathematical problem is similar to taking a test. However, they noted that mathematics anxiety is not exactly the same as test anxiety.

Richardson and Woolfolk (1980) observed that math anxiety is a reaction to content, as well as to evaluation. They went on to suggest that the science of mathematics is somewhat mystical:

> The science of mathematics, "being good" at math or liking it connotes certainty, perfection, high intelligence, genius, arcane wisdom, highly specialized knowledge remote from common sense, monotonous and mechanical problem solving, the key to ultimate truth, something antagonistic to humanistics values, the essence of practicality, something essentially irrelevant to everyday life, a characteristically masculine activity, or a decidedly unfeminine activity--in varying and more or less consistent combinations of meanings. (p.271-272)

They concluded that given these connotations, the fact that mathematics has the potential for causing anxiety among individuals is not surprising.

Richardson and Woolfolk (1980) also speculated that phobias such as "biology anxiety" and "English-literature anxiety" are not prevalent because these areas of study are typically not considered to be as complicated or abstract as the study of mathematics. Furthermore, Richardson and Suinn (1972) observed that mathematics anxiety was the only form of anxiety exhibited by some individuals. Suinn (as cited in Richardson & Suinn, 1972) reported that more than one-third of the students participating in a university-sponsored behaviour therapy program acknowledged that their problems centered around mathematics anxiety.

The cause of mathematics anxiety has not been clearly identified according to previous research. It appears likely that a multitude of events could serve as potentially contributing factors. For example, previous exposure to mathematics has been suggested as a possible cause of mathematics anxiety (Betz, 1978; Richardson & Woolfolk, 1980). Betz (1978) reported statistically significant correlations ($\underline{r}$ =.19 to $\underline{r}$ =.43) between number of years of high school math and level of mathematics anxiety for three groups of college students. The students were enroled in undergraduate courses in basic mathematics, advanced mathematics, or introductory psychology. The specific correlation associated with each group was not reported. Betz (1978) concluded that the amount of mathematics preparation received during high school serves as a moderately strong influence on how a college student will feel about mathematics.

Hembree (1990) conducted a meta-analysis of 151 studies investigating mathematics anxiety among elementary, secondary, and post-secondary students. He found that positive attitudes toward mathematics were consistently associated with lower mathematics anxiety. Furthermore, strong inverse relationships were observed between enjoyment and self-confidence in math and mathematics anxiety (Hembree, 1990). Similarly, Cooper and Robinson (1991) reported that mathematics self-efficacy or perceived mathematics ability served as a potentially causal factor of mathematics anxiety for 229 female undergraduate college students in mathematics-oriented programs.

Rounds and Hendel (1980) stated that a persistent difficulty with mathematics anxiety research pertains to the ambiguity of the construct. They claimed that these ambiguities directly relate to a lack of consensus among researchers with regard to the conceptualization of anxiety in general and mathematics anxiety, more specifically. Richardson and Suinn (1972) defined math anxiety as "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (p. 551). Later, Tobias and Weissbrod (1980) stated that the term mathematics anxiety has traditionally been used "to describe the panic, helplessness, paralysis, and mental disorganization that arises among some people when they are required to solve a mathematical problem" (p. 65). Another description, offered by Tobias (1978) and Williams (1988), characterizes math anxiety as both an emotional and a cognitive dread of mathematics. At this point, it is concluded that mathematics anxiety is comprised of a combination of unpleasant factors that lead to feelings of tension, apprehension, and incompetence.

Assessment of Mathematics Anxiety

As with other constructs, the assessment of mathematics anxiety has contributed to the development of this concept as a construct. Instruments for the assessment of mathematics anxiety have been developed by Dreger and Aiken (1957), Richardson and Suinn (1972), and Fennema and Sherman (1976). Rounds and Hendel (1980) noted that both Dreger and Aiken's (1957) Numerical Anxiety Scale and Fennema and Sherman's (1976) Mathematics Anxiety Scale lack reliability and validity data. However, a substantial amount of psychometric data are available for Richardson and Suinn's (1972) Mathematics Anxiety Rating Scale (MARS; see Richardson & Suinn, 1972; Suinn, Edie, Nicoletti, &

Spinelli, 1972). These data help to clarify not only the performance of the MARS as a measure of mathematics anxiety, but also mathematics anxiety as a construct.

The Mathematics Anxiety Rating Scale (MARS) is comprised of 98 Likert-type items which describe everyday and academic situations involving the manipulation of numbers or mathematical problem-solving. A wide variety of situations are included in the instrument to ensure that it is applicable to a diverse group of consumers, including both students and nonstudents. Two sample items are as follows:

> Deciding how much change you should get back from buying several items. (MARS #1)
>
> Asking your math teacher to help you with a problem that you don't understand. (MARS #95)

Participants use a 5-point Likert scale (1=not at all, 2=a little, 3=a fair amount, 4=much, and 5=very much) to rate their current level of anxiety regarding each of the statements. A total mathematics anxiety score is calculated by summing the scores for the 98 items. The MARS provides mathematics anxiety scores which range from 98 to 490.

Richardson and Suinn (1972) administered the MARS to 397 freshman and sophmore university students enroled in introductory education courses. The mean and standard deviation of MARS scores for this sample were 215.38 and 65.29, respectively. The internal consistency reliability, assessed using coefficient alpha (Nunnally, 1967), was .97 (Richardson & Suinn, 1972). They reported a seven week test-retest reliability coefficient of .85, calculated from the scores of the students in two classes ($\underline{n}$ = 35) from the original sample. In a separate study, Suinn et al. (1972) found a test-retest correlation of .78 with 119 college students tested two weeks apart.

Evidence of the validity of the MARS was established by both Richardson and Suinn (1972) and Suinn et al. (1972) by correlating total scores with scores on the mathematics form of the Differential Aptitude Test (Bennett, Seashore, & Wesman, 1984). The mathematics form of the Differential Aptitude Test is made up of mathematical problems that range from simple to increasingly complex. Richardson and Suinn (1972) administered the instruments to a sample of 30 junior and senior university students enroled in an advanced undergraduate psychology course. The correlation between subjects' scores on the two instruments was -.64 ($\underline{p}$ <.01). Suinn et al. (1972) collected data from 119 university students and found a correlation of -.35 ($\underline{p}$ <.05). High MARS scores were associated with poor performance on the mathematics test and, according to Richardson and Suinn

(1972), this finding indicated that the MARS measured mathematics anxiety. Further evidence of the validity of the MARS was demonstrated by the fact that students' MARS scores showed statistically significant decreases following behaviour therapy for mathematics anxiety (Richardson & Suinn, 1972, p. 553).

Dimensionality of Mathematics Anxiety

Although the MARS appears to be the most commonly used instrument to assess mathematics anxiety, some disagreement is evident with regard to the factorial nature of the MARS and, consequently, the construct of mathematics anxiety. Richardson and Suinn (1972) and Suinn et al. (1972) reported that mathematics anxiety, as measured by the MARS, is a unidimensional construct. Subsequently, Richardson and Woolfolk (1980) performed a principal components factor analysis, with varimax rotation, on the original data from the Richardson and Suinn (1972) study and concurred that a single factor existed. They found one distinct factor which accounted for 76% of the variance. Richardson and Woolfolk (1980) concluded that mathematics anxiety is dominated by a single homogeneous factor pertaining to "evaluative test-taking and problem-solving mathematics situations" (p. 274).

However, other researchers have found contradictory results, obtaining from two to six factors. Rounds and Hendel (1980), for example, used a 94 item form and administered it to a sample of 350 female university students. Four of the items were omitted from the original version of the MARS due to a printing error. They performed principal-axes factor analysis in which squared multiple correlations were used as communality estimates. Both direct oblimin transformation and varimax rotation resulted in two factors: Mathematics Test Anxiety and Numerical Anxiety. They reported that the most salient items for Factor 1 (Mathematics Test Anxiety) referred to "anticipation, completion, and receiving the results of mathematics tests" (Rounds & Hendel, 1980, p. 145). The most salient items for Factor 2 (Numerical Anxiety) involved everyday situations necessitating some form of numeric manipulation. These factors accounted for approximately 29% and 8% of the common variance of the MARS scores, respectively.

Rounds and Hendel (1980) proceeded to reduce the number of items contained in the original MARS by developing two factor-derived scales, each containing 15 items. They found that coefficient alpha was .93 for the Mathematics Test Anxiety Scale and .87 for the Numerical Anxiety Scale. Rounds and Hendel (1980) pointed out that these coefficients compare favourably with the .97 coefficient alpha for the original 98-item MARS (Richardson & Suinn, 1972). They concluded that mathematics anxiety as conceptualized by Richardson and Suinn (1972) can be measured with the two factor-derived scales (Rounds & Hendel, 1980).

Plake and Parker (1982) also obtained two factors using a reduced version of the MARS. Their objective was to examine "mathematics-type anxiety in a statistics class" (p. 552). To achieve this goal, they selected 24 items from the original MARS instrument. Plake and Parker claimed these 24 items were specific to "anxiety in a statistically related situation" (1982, p. 552). However, it should be noted that 22 of the items had no relevance to statistics; these items referred to situations in a mathematical context.

The items were administered to 170 students enroled in an introductory statistics class. The item responses were factor analyzed using the principal factor technique with squared multiple correlations as communality estimates. Varimax rotation yielded two factors: Learning Mathematics Anxiety and Mathematics Evaluation Anxiety. Plake and Parker (1982) reported that this two-factor solution accounted for 60% of the common variance. They observed that the first factor referred to activities related to the study of statistics, while the second factor contained items associated with the evaluation of mathematics or statistics learning.

Resnick, Viehe, and Segal (1982) found three factors when they analyzed the responses of 1,045 freshmen university students to the 98-item version of the MARS. Principal component analysis and varimax rotation resulted in three factors labelled Evaluation Anxiety, Social Responsibility Anxiety, and Arithmetic Computation Anxiety. Together, these three factors accounted for approximately 32%, 5%, and 4% of the total variation, respectively. Resnick et al. (1982) reported that the Evaluation Anxiety factor contains items which involve anticipating and receiving mathematical work to be evaluated, particularly tests. The Social Responsibility Anxiety factor includes items which refer to being responsible for financial or arithmetic matters in clubs and organizations. The third factor, Arithmetic Computation Anxiety, has items related to everyday situations which require numeric manipulation.

Ferguson (1986) also recognized three factors which characterize mathematics anxiety. He speculated that the factors identified by Rounds and Hendel (1980) may not be the defining components of mathematics anxiety. Specifically, Ferguson (1986) hypothesized that reaction to abstract mathematical issues would be a factor of this construct. He assimilated components of Rounds and Hendel's (1980) findings by using 10 of the MARS items they identified as loading heavily on Mathematics Test Anxiety and 10 items loading heavily on Numeric Anxiety. These items were combined with 10 items developed by Ferguson (1986) to refer to more abstract mathematical concerns. The 30 items were used to form a mathematics anxiety inventory titled Phobos. The Phobos was administered to 365 college students enroled in mathematics courses (Ferguson, 1986).

The data were factor analyzed using two different methods. First, a principal-axes factor analysis was performed, followed by a varimax rotation. The selection of communality estimates was not provided by the author. The second analysis involved an alpha extraction with an equamax transformation. Both factor analyses resulted in three factors labeled Abstraction Anxiety, Numerical Anxiety, and Mathematics Test Anxiety. These three factors accounted for 11%, 8%, and 7% of the common variance, respectively. The Numerical Anxiety and Mathematics Test Anxiety factors were similar in structure to those found by Rounds and Hendel (1980). It is interesting to note that the hypothesized Abstraction Anxiety factor made the greatest contribution to the variability in the Phobos scale (Ferguson, 1986). Two additional factors were obtained from the Phobos data; however no attempt was made to interpret these factors.

A few researchers have tried to expand the notion of the multidimensionality of mathematics anxiety. For example, Bessant (1995) used a slightly reduced 80-item version of the MARS to collect data from 173 university students enroled in introductory statistics courses. Information regarding the type of factor analysis utilized was not provided by the author. However, quartimax rotations were used. Six factors were found, several of which are referred to as "fringe" factors by the author. According to Bessant (1995) "fringe" factors refer to factors that are small, accounting for a negligible amount of the total variance. He labeled the factors General Evaluation Anxiety, Everyday Numerical Anxiety, Passive Observation Anxiety, Performance Anxiety, Mathematics Test Anxiety, and Problem-Solving Anxiety. These factors accounted for 28.09%, 6.71%, 3.09%, 2.84%, 1.78%, and 1.45% of the total variance of the scores, respectively. The author did not state which of these factors were identified as "fringe", however based on the percentage of variance accounted for, it would appear that only the first two factors were significant.

The debate regarding the dimensions of mathematics anxiety will likely continue. The only point of consensus appears to be that the MARS is measuring anxiety that is more than simply test anxiety (Brush, 1978). Regardless of disagreement of the exact dimensionality of the construct and of the MARS, this instrument continues to be a popular assessment tool used by practitioners and researchers to identify math anxious students (Ferguson, 1986; Plake & Parker, 1982). Furthermore, in relation to other mathematics anxiety instruments, the MARS has the greatest amount of psychometric reliability and validity data (D'Ailly & Bergering, 1992).

Mathematics Anxiety and Mathematics Performance

Research examining the relationship between mathematics anxiety and achievement in mathematics has resulted in some inconsistent findings. The association between these constructs was examined by Betz (1978) using three samples of students. These students were enroled in three different university courses: introductory psychology (47 males and 73 females), basic mathematics (32 males and 52 females), and advanced mathematics (153 males and 116 females). The specific nature of the advanced mathematics course was not provided. Math anxiety was assessed using a modified 10-item scale taken from the Fennema-Sherman Mathematics

Attitudes Scales (Fennema & Sherman, 1976). This instrument was designed to measure feelings of dread and anxiety, as well as physical symptoms exhibited by students when confronted with doing mathematics (Fennema & Sherman, 1976). High scores on this scale represent more positive attitudes toward mathematics and less mathematics anxiety. Mathematics achievement was evaluated using scores on the Mathematics subtest of the American College Test (ACT).

In the introductory psychology group, the relationship between mathematics anxiety and achievement was significant for females (r =.42, p <.001) but not for males (r =.17). Nonsignificant correlations were obtained for both males and females in the basic mathematics group (r =.26 and r =.21, respectively). The strongest relationship between mathematics anxiety and achievement was observed for students in the advanced mathematics group. The correlations were .38 for males and .34 for females (p <.001). Betz concluded that "there was a general tendency for higher levels of math anxiety to be associated with lower math achievement test scores" (1978, p. 445).

Similar conclusions regarding the relationship between math anxiety and achievement were found by Hembree (1990). He employed meta-analysis to integrate the results of 151 studies investigating the effects of mathematics anxiety on students' performance. The following criteria were used by Hembree (1990) to determine inclusion of studies in his meta-analysis:

> 1. The study report provided product-moment correlation coefficients and their sample sizes or, in the case of experiments, sufficient data for effect-size calculations.
>
> 2. Mathematics anxiety measurements were made with validated instruments.
>
> 3. Experiments used at least two groups, including a control.
>
> 4. Each experimental group contained at least 10 subjects (for rigor in the meta-analytic tests of homogeneity). (p.35)

Higher levels of mathematics anxiety were consistently related to lower math performance, across all grade levels. For grades 5 to 12, the results of six studies with male subjects (N = 2,794) and six studies using only female subjects (N = 2,864) were compared. Hembree (1990) observed that the inverse relationship was slightly stronger for males than females (mean r = -0.36 and mean r = -0.30 respectively; p <.01). Differences between males and females were not evident among the 58 studies (N = 6,137) involving college students.

Hembree (1990) also investigated the relationship between math anxiety and performance with regard to effect size. Thirteen studies comparing the test scores of college students with high and low mathematics anxiety were examined. The mean of the 13 effects was -0.61 indicating that students with low math anxiety consistently performed better than the high-anxious students. Hembree explained that "effect size represents the number of pooled standard deviations between the scores of the two groups being compared" (1990, p. 42). He assumed a pooled standard deviation of 12 for scores on a 100-point scale. Thus, the mean effect size illustrated a difference of approximately 7 points in math performance between the two anxiety groups. Based on the results of the meta-analysis, Hembree (1990) concluded that math anxiety caused a reduction in mathematics performance. However, he found no compelling evidence to suggest that poor performance resulted in mathematics anxiety.

Morris, Kellaway, and Smith (1978) also examined the relationship between mathematics anxiety and academic performance. They administered a 94-item version of the MARS to 54 mathematics students enroled in second and third year university mathematics courses and 52 psychology students enroled in two introductory statistics courses.

Performance was assessed using the students' first and final exam grades, as well as their overall course grade. These exams were specific to each of the courses.

Total MARS scores were not significantly associated with the mathematics students' performance as assessed by first exam grade, final exam grade, or course grade. The correlations were -.21, -.21, and -.22, respectively. For the psychology students, mathematics anxiety was significantly related to final exam grade and course grade (in order, $r = -.37$ and $r = -.30$, $p < .05$), but not to first exam grade ($r = -.11$). Morris, Kellaway, and Smith (1978) concluded that mathematics anxiety had only an indirect effect on performance and that this effect was unlikely to be found consistently in specific situations.

Other researchers have concurred that the relationship between math anxiety and performance is somewhat ambiguous. For example, Aiken (1976) stated that the use of affective variables, such as math anxiety, to predict achievement in mathematics would usually result in significant, but weak correlations. Zeidner (1991) examined the relationship between recalled mathematics anxiety in high school, self-reported high school matriculation grades in mathematics, and perceived mathematics ability of 431 undergraduate university students who had taken a required introductory course in statistics. Recalled mathematics anxiety in high school was found to have significant, weak to moderate correlations with mathematics achievement, and perceived mathematics ability ($r = -.24$ and $r = -.49$, $p < .05$, respectively).

In summary, although anxiety regarding mathematics and quantitative concepts does not appear to be directly related to achievement, it can serve as a potentially adverse influence with regard to students' academic experiences. Hembree (1990) and Richardson and Suinn (1972) observed that higher levels of mathematics anxiety were significantly related to lower levels of mathematics achievement. Betz referred to mathematics anxiety as a "critical factor" in the educational and occupational goals and decisions of some students (1978, p.441). Consequently, the effect of mathematics anxiety as an influential factor on academic outcome, though inconclusive, appears to merit continued investigation.

Statistics Anxiety

Statistics Anxiety as a Construct

In contrast to the abundance of research conducted in the area of mathematics anxiety, statistics anxiety has received meagre attention. This apparent deficiency of research is further complicated by the lack of clear differentiation between statistics anxiety and statistics test anxiety. Statistics anxiety has been defined by Cruise, Cash, and Bolton as feelings of anxiety experienced when taking a statistics course or performing statistical analyses (1985, p. 92). Zeidner described statistics anxiety as feelings of "extensive worry, intrusive thoughts, mental disorganization, tension, and physiological arousal" that interfere with the ability to cope with statistics content, problems, instructional situations, or evaluative contexts (1991, p. 319). Statistics anxiety has also been referred to as "mathematics-type" anxiety exhibited in a statistics course (Plake & Parker, 1982, p. 552).

An overview of the research directed toward the assessment of statistics anxiety is presented in the next section. Following this discussion, research which addresses statistics test anxiety and the effect of statistics anxiety on performance is presented.

Assessment of Statistics Anxiety

A small number of studies have investigated statistics anxiety by means of instruments developed to assess mathematics anxiety. As mentioned previously in the section on dimensionality of mathematics anxiety (see pp. 34), Plake and Parker (1982) used 24 items from the MARS to measure math anxiety in statistically related situations. It was noted there that 22 of the 24 items chosen for inclusion in their study had no direct association with statistics, _per se_, but rather referred to mathematics in general. Consequently, the construct being examined was actually mathematics anxiety in a statistics course.

Expanding upon the use of a mathematics anxiety instrument to assess statistics anxiety, Zeidner (1991) administered a modified and condensed 40-item version of the MARS to 431 undergraduate students who had already completed a required course in statistics and were not statistics majors. The 40 items, referred to as the Statistics Anxiety Inventory (SAI), were constructed to describe potentially anxiety-provoking situations related to statistics in the behavioral sciences.

The modification of the MARS items consisted of replacing the word "mathematics" with the word "statistics". Furthermore, these items were selected to reflect two hypothesized dimensions of statistics anxiety: "anxiety about statistics content and anxiety about statistics performance and problem-solving capacity in evaluative situations" (Zeidner, 1991, p.321).

Principal-axes factor analysis was performed in which squared multiple correlations were used as communality estimates. Information regarding the type of rotation or transformation employed was not provided by the author, however the analysis resulted in two factors: Statistics Content Anxiety and Statistics Test Anxiety. These factors accounted for 24% and 21% of the common variance, respectively. Based on these results Zeidner conceptualized statistics anxiety as a two-factor construct: one component representative of statistics content anxiety and the other reflecting statistics test anxiety.

Zeidner (1991) reported that the two factors of his Statistics Anxiety Inventory corresponded to the two factor structure underlying mathematics anxiety, as reported by Rounds and Hendel (1980). He concluded from these findings that parallels exist between statistics anxiety and mathematics anxiety.

Zeidner (1991) also examined the relationship between students' perceived degree of success in high school math (1=failure, 10=extreme success), perceived mathematics ability (1=way below average, 5=way above average), and perceived degree of math anxiety in high school (1=not at all, 5=to great extent). For each of these three items the author reported only the definitions of the endpoints; he did not provide information regarding the intermediate values. Zeidner reported that a significant but weak negative relationship existed between statistics anxiety and success in high school math ($r = -.13$, $p < .05$). He also found that statistics anxiety was inversely related to perceived math ability ($r = -.38$, $p < .05$), and positively associated with math anxiety ($r = .41$, $p < .05$). Zeidner (1991) presented these findings as additional evidence in support of the similarities between mathematics anxiety and statistics anxiety; similar relationships for success in high school math and perceived math ability have been reported for mathematics anxiety (see pp. 39-42).

Also advancing the use of a mathematics anxiety instrument to measure statistics anxiety, Pretorius and Norman (1992) modified the 10-item Mathematics Anxiety Scale (MAS) developed by Betz (1978) by replacing the word "mathematics" with "statistics" in each of the test items. This scale was then referred to as the Statistics Anxiety Scale (SAS). Subjects used a 5-point Likert scale (1=strongly agree to 5=strongly disagree) to rate their level of anxiety regarding each of the statements. According to Pretorius and Norman (1992), high scores on the SAS would be indicative of a high level of statistics anxiety. The instrument was administered to 337 third-year Psychology students. The authors do not specify whether these students were currently enroled in a statistics course or had already completed a statistics course.

Pretorius and Norman (1992) analyzed the levels of statistics anxiety for 268 students. The authors do not explain the reason for the decreased sample size. Within this subsample, a significant difference in statistics anxiety was found to exist between students who passed a statistics course and those who failed ($t(266) = 2.24$, $p < .05$). As well, SAS scores were positively related to trait anxiety ($r = .26$, $p < .05$), as measured by the A-trait scale of the State-Trait Anxiety Inventory (Spielberger, 1980). The state anxiety scale of Spielberger's instrument was not used in the study. According to Pretorius and Norman (1992) this finding parallels the conclusion reached by Betz (1978); individuals inclined to be anxious in a variety of situations (e.g., higher levels of trait anxiety) are more apt to report feelings of math anxiety.

Assessment of Statistics Test Anxiety

Benson (1989) examined the relationships between math self-concept, self-efficacy, achievement, general test anxiety, and statistics test anxiety. The measures of math self-concept and self-efficacy were developed by the author and each used a 5-point Likert-type scale as the response format. The math-self concept scale was comprised of seven items and the self-efficacy scale contained three items. Achievement was based on students' mid-term exam grades. The Test Anxiety Inventory (TAI) (Spielberger, 1980) was used to assess both general test anxiety and statistics test anxiety.

The TAI uses a Likert-type response format and provides the following directions: "Respond to the items based upon how you feel when you take *any* test". Sixteen items from this 20-item instrument were shown to comprise a worry factor and an emotionality factor, each composed of 8 items (Spielberger, 1980). General test anxiety was measured using these 16 items, based on the two factors. Statistics test anxiety was assessed by means of the same 16 items and the following modified instructions: "Respond to the items based upon the test *you have just taken*".

The four instruments were administered to 125 undergraduate and 94 graduate students, enroled in three different statistics course. Each of the instruments was found to demonstrate internal consistency as measured using Cronbach's α. Math self-concept (α = .90), self-efficacy (α = .78), and general test anxiety (α = .89) were assessed during the first week of classes. The statistics test anxiety instrument was administered immediately following the mid-term exam ($\alpha = .92$).

Statistics test anxiety was found not to be significantly different between undergraduate and graduate students. The correlation between general test anxiety and statistics test anxiety was $r = .66$ (p-value was not reported). Consequently Benson (1989) noted that, similar to the findings for math test anxiety, the constructs of statistics test anxiety and general test anxiety are similar, but distinct. However, it should be noted that the two measures were administered at different times, which could serve to lower the correlation.

Benson (1989) conducted further analyses using Lisrel VII (Jöreskog & Sörbom, 1988). The paths from undergraduate/graduate status to statistics test anxiety and from self-efficacy to statistics test anxiety were not significant. The significant paths ($p < .05$), and corresponding standardized coefficients and standard errors, were as follows: high math self-concept associated with low statistics test anxiety (path coefficient = -.214, standard error = .451); high achievement with low statistics test anxiety (path coefficient = -.188, standard error = .039); and high general test anxiety with high statistics test anxiety (path coefficient = .515, standard error = .090). Benson (1989) concluded that aside from the consideration of math self-concept, general test anxiety, and statistical test anxiety as affective components, and self-efficacy and achievement as cognitive components, additional affective and cognitive variables needed to be examined to further understand statistical test anxiety.

Expanding upon the above research, Benson and Bandalos (1989) considered a different set of predictor variables~~,~~ namely math self-concept and self-efficacy (Benson, 1989), computer anxiety, number of prior math courses, and general test anxiety. The 23-item, 5-point computer anxiety scale was a modified version of an instrument developed by Loyd and Gressard (1984). To measure general test anxiety, Benson and Bandalos (1989) took 8 items which assessed worry on the TAI (Spielberger, 1980) and 6 items from the Test-Irrelevant Thinking subscale of the Reactions to Tests (RTT; Sarason, 1984). They then modified the 14 items so that the object of anxiety was a statistics test.

Benson and Bandalos (1989) utilized these test anxiety items based on the speculation that "test anxiety might be better operationalized by the interfering thoughts of worry and distractability" (p.141). The 14 items were used to measure general test anxiety with the following instructions: "Respond to the items based upon how you feel when you take *any* test". Statistics test anxiety was assessed by means of the same 14 items with the directions to "Respond to the items based upon how you feel when taking a statistics test". The five scales were administered to 161 undergraduate and 184 graduate students during the first two weeks of class. The authors did not indicate the courses in which these students were enroled. High scores on the math self-concept and self-efficacy scales indicated high math self-concept and high self-efficacy. High scores on the computer anxiety, general test anxiety, and statistical test anxiety instruments represented high levels of anxiety.

The resulting data were analyzed using Lisrel VII (Jöreskog & Sörbom, 1988). The following significant paths (p <.05), and the corresponding standardized coefficients and standard errors, were found to differentiate between undergraduate and graduate students: graduate students had higher levels of self-efficacy (path coefficient = .13, standard error = .07) and statistics test anxiety (path coefficient = .12, standard error = .05), undergraduates had higher levels of general test anxiety (path coefficient = -.19, standard error = .07). Prior number of math courses was found to be significantly associated (p <.05) with math self-concept (path coefficient = .36, standard error = .03), self-efficacy (path coefficient = .16, standard error =

.02), and computer anxiety (path coefficient = .16, standard error = .16); additionally lower levels of math self-concept resulted in lower levels of self-efficacy (path coefficient = .66, standard error = .05).

With regard to statistical test anxiety specifically, the following significant paths (*p* < .05), with the corresponding standardized coefficients and standard errors, were observed: lower levels of self-efficacy resulted in higher statistical test anxiety (path coefficient = -.15, standard error = .02), lower levels of math self-concept related to higher levels of statistical test anxiety (path coefficient = -.27, standard error = .03), higher levels of computer anxiety were associated with higher levels of statistical test anxiety (path coefficient = .21, standard error = .01), and higher general test anxiety resulted in higher statistical test anxiety (path coefficient = .62, standard error = .06). Benson and Bandalos concluded that statistical test anxiety could be differentiated from general test anxiety. Furthermore, general test anxiety was reported to have the largest effect on statistical test anxiety, followed by math self-concept, computer anxiety, and self-efficacy.

While the above mentioned studies provide some insight with regard to potential anxieties associated with taking a statistics course, to reiterate these investigations focused on statistics test anxiety rather than general statistics anxiety. Richardson and Woolfolk (1980) claimed that statistics anxiety is distinct from test anxiety because it involves an individual's reaction to content, as well as performance evaluation.

Statistics Anxiety and Statistics Performance

The effect of statistics anxiety on statistics course performance has been investigated in several critical review papers (e.g., Bradstreet, 1996; Chmielewski & Chmielewski, 1983). Bradstreet (1996) reported that statistical anxiety may have a greater impact on the performance of graduate students than undergraduate students. He reasoned that the realization by graduate students that data analysis would be an important part of their research would consequently increase their anxiety levels. Furthermore, students with limited experience in quantitative courses or lack confidence in their ability to perform in such courses may be particularly prone to statistics anxiety (Chmielewski & Chmielewski, 1983). Chmielewski and Chmielewski (1983) predicted that if excessive, this anxiety will interfere with the process of learning.

Feinberg and Halperin (1978) examined the relationship between affective and cognitive factors and statistics course performance. An instrument to assess attitudes toward quantitative concepts, a basic mathematics achievement test, the State-Trait Anxiety Inventory, and a demographic questionnaire were administered to 209 undergraduate and 69 graduate students enroled in four sections of an introductory statistics course. The students were also asked to rate their perceived mathematical ability relative to other students in their statistics class (PERCA), as well as fellow students in their major area of study (PERCB), and their expected final grade for the statistics course. Demographic information included sex, age, number of previous math courses, and success in previous math courses. Course performance was assessed by students' actual grades achieved in the course. Feinberg and Halperin (1978) hypothesized specifically that course achievement in introductory statistics would be related to two affective variables, state anxiety (-) and attitudes toward quantitative concepts (+), and two cognitive variables, basic mathematics achievement (+) and expected grade outcome (+).

Course performance was found to be significantly correlated in a negative direction with state anxiety ($\underline{r} = -.22$, $\underline{p} < .01$), however a significant relationship was not found between course performance and trait anxiety. A gender difference was observed in that males achieved significantly higher course performance than females ($r = -.18$, $p < .01$). Course performance was positively related ($p < .01$) to basic mathematics achievement ($r = .40$), attitude toward quantitative concepts ($r = .35$), expected course grade ($r = .33$), number of previous math courses ($r = .31$), success in previous math courses ($r = .34$), PERCA ($r = .33$), and PERCB ($r = .25$). Feinberg and Halperin concluded that success in introductory statistics courses appeared to be a function of a variety of cognitive and affective factors.

Comparison of Response Formats

One of the most commonly used response formats, particularly for research which examines factors within the affective domain, is the Likert scale (DeVeillis, 1991; Hopkins, Stanley, & Hopkins, 1990). In fact, all of the mathematics anxiety and statistics anxiety research discussed in the previous sections employed Likert formats. Each of these formats utilized a scale which provided five response categories. The popularity of the five-point Likert scale is likely due in part to its familiarity to research participants, its ease of use, and ease of scoring.

However, research is lacking in the assessment of whether a different response format would result in different outcomes.

A response format more commonly used in medical research is the visual analogue scale. This response format has been employed extensively to measure pain, mood, and functional capacity (Streiner & Norman, 1992). Following each item on a visual analogue scale the respondents are presented with a line of fixed length, usually 100 mm, between a pair of descriptors representing opposite ends of a continuum (DeVeillis, 1991). The respondents are instructed to place a mark at the point on the line that best represents their response.

Proponents of the visual analogue scale claim this type of response format is a more sensitive or precise form of measurement compared to scales such as the Likert (Mayer as cited in DeVellis, 1991). However, Streiner and Norman (1992) observed that data from the two methods typically produce a substantial correlation.

Similar comparisons have not been made with regard to different response formats in the measurement of affective factors such as statistics and mathematics anxiety. Research has not examined whether different response formats would result in different levels of anxiety. Consequently, this is an area within the study of statistics and mathematics anxiety which needs to be addressed.

Summary

To summarize the preceding chapter, the recognition and examination of anxiety as an important concept has been evident since early history and continues to receive considerable research attention today. Anxiety associated specifically with academic courses such as mathematics and statistics has been investigated. However statistics anxiety is frequently assessed by means of instruments which have been designed to measure mathematics anxiety. While it is reasonable to assume that a relationship exists between statistics and mathematics anxiety, there is no evidence to conclude that these two constructs are interchangeable. The specific similarities and differences between statistics anxiety and mathematics anxiety have not been methodically examined. Furthermore, the issue of whether different measurement strategies result in different levels of statistics anxiety and mathematics anxiety has been neglected and needs to be investigated.

CHAPTER III: METHOD

A survey, combined with interviews of a subsample of the survey participants, was utilized to address the questions presented in Chapter I. This combined approach fits the requirements to address these questions in that the procedure involves the measurement of perceived anxiety rather than the applications of two or more treatments designed to influence or otherwise change behaviour. Students' anxiety about statistics and their anxiety about mathematics were assessed by administering two forms of a common instrument. These forms differed in the way the students responded: Likert scale and visual analogue scale. The interviews were used to clarify and illuminate the survey results. The responses to the survey instruments and from the interviews were used to identify and clarify the differences and similarities that existed between statistics anxiety and mathematics anxiety.

The procedures used are described in the present chapter. The development of the two forms of the instrument to measure statistics and mathematics anxiety are described first, followed by a description of the State-Trait Anxiety Inventory and the demographic questionnaire that were administered. This information is followed by descriptions of the population of interest, selection of subjects, and data collection procedures. The chapter concludes with a description of the data preparation and the preliminary analyses, including results, conducted prior to the main analyses.

Instruments

Statistics-Mathematics Anxiety Comparison Scales

Two scales were developed, one to measure statistics anxiety and the other to measure mathematics anxiety. These scales were referred to as the Statistics-Mathematics Anxiety Comparison Scales (SMACS). Two forms of each scale were then produced to represent two different assessment strategies. The assessment forms were similar in that a common set of items was used with each strategy. The first form employed a 5-point Likert scale, while the second used a visual analogue scale. The purpose of using the two response formats was to investigate whether different methods of assessment produce different results with regard to distinguishing between statistics and mathematics anxiety. For the purposes of this study, the two instruments for assessing statistics anxiety and mathematics anxiety were referred to as SMACS-5PT and SMACS-VAS, respectively. The two constructs were statistics anxiety and mathematics anxiety.

SMACS-5PT

The statistics and mathematics anxiety Likert scales (SMACS-5PT) consisted of 24 items from the Mathematics Anxiety Rating Scale (Suinn, 1972).[1] These items were selected based on the research conducted by Plake and Parker (1982) and discussed in the previous chapter (see pp. 34). Their findings were also used as the rationale for the construction of two subtests. Plake and Parker (1982) described a 16-item "learning mathematics anxiety" subtest and an 8-item "mathematics evaluation anxiety" subtest within the 24 items. For the purposes of this study the two subtests were retained and subsequently referred to as the course content anxiety subtest and the evaluation anxiety subtest, respectively. Plake and Parker (1982) reported an internal consistency (coefficient alpha) reliability of .98 ($\underline{M}$ = 59.44, $\underline{SD}$ = 20.55) for the 24 items; reliability estimates were not provided for the two subtests.

The 24 statistics anxiety items were adapted from the 24 mathematics anxiety items. Each of the mathematics anxiety items was rewritten to depict a parallel situation in the context of a statistics course. Most often the nature of this revision was simply the replacement of the word "mathematics" with "statistics", as illustrated in the sample item shown in Panel A of Figure 1. Seven of the adopted MARS items received minor revisions to assist in the clarification of mathematics and statistics situations, or to make the statements more meaningful to graduate students. An example of this type of change is shown in Panel B of Figure 1.

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[1] Permission to use this copyrighted instrument was obtained on August 1, 1996 from the author, Richard M. Suinn.

The SMACS-5PT utilized the same 5-point Likert-type response format employed for the original MARS (Suinn, 1972) and retained by Plake and Parker (1982). The response options are as follows: 1=not at all; 2=a little; 3=a fair amount; 4=much; 5= very much. Subjects were asked to rate or indicate how much anxiety they felt regarding the situation depicted in each item. Figure 2 provides the instructions for the SMACS-5PT, an example of the response format, and sample items. A copy of the SMACS-5PT is provided in Appendix A.

SMACS-VAS

When responding to measures such as Likert-type scales a concern sometimes expressed by individuals is that occasionally the preferred response to an item falls between

Panel A:

Item 26 from the original MARS, used in the SMACS-5PT.

Signing up for a course in mathematics.

Rewritten item to depict parallel situation in a statistics course.

Signing up for a course in statistics.

Panel B:

Item 91 from the original MARS.

Being given a "pop" quiz in a math class.

Revised item used in the SMACS-5PT.

Being given an unexpected quiz in a math class.

Rewritten item to depict parallel situation in a statistics course.

Being given an unexpected quiz in a statistics class.

Figure 1. Sample items from the SMACS-5PT.

Instructions:

Each of the statements below refers to classroom or course situations which may cause anxiety for some students. Anxiety is often described as feelings of dread and apprehension without specific cause for the fear (Chaplin, 1985). Feelings of anxiety vary in degree or intensity, depending on the individual and the situation. Anxiety is associated with negative or unpleasant emotions.

Read each statement carefully, then place a check (✓) in the box under the column that describes how much anxiety you currently feel regarding each situation. Your first response is usually the best one.

Sample Items:

	Not at all	A little	A fair amount	Much	Very much
Signing up for a course in mathematics.	☐	☐	☐	☐	☐
Signing up for a course in statistics.	☐	☐	☐	☐	☐

Figure 2. Instructions for the SMACS-5PT, examples of the response format, and sample items.

two of the options provided (e.g., somewhere between strongly agree and agree). Therefore, a second assessment strategy for comparing statistics anxiety and mathematic anxiety was developed. The SMACS-VAS consisted of the same statements used in the SMACS-5PT, and utilized a visual analogue scale as the response format. The visual analogue scaling method was selected to enable respondents greater flexibility in their responses to each statement and to provide a continuous measurement.

Subjects responded to each item in the SMACS-VAS using a scale comprised of a 101 mm line with anchors of _not at all anxious_ and _very anxious_ for each item. Originally the visual analogue lines were created to equal 100 mm, however the photocopy process to produce multiple copies of this instrument altered the line length to 101 mm. The instructions for the SMACS-VAS and examples of how to use a visual analogue scale are found in Figure 3. In the first example the subject has displayed a relatively high level of anxiety with regard to how s/he would feel about this situation. In the second example, the subject has rated this situation as causing no anxiety. A copy of the SMACS-VAS is provided in Appendix B.

The responses to the 24 items in the two versions of the SMACS-VAS were used to compare the degree to which

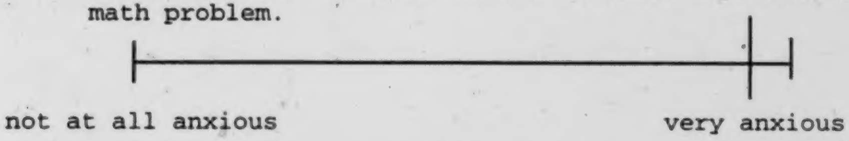
Instructions:
Each of the statements below refers to a classroom or course situation which may cause anxiety for some students. Anxiety is often described as feelings of dread and apprehension without specific cause for the fear (Chaplin, 1985). Feelings of anxiety vary in degree or intensity, depending on the individual and the situation. Anxiety is associated with negative or unpleasant emotions.

For each item, carefully read the statement and the anchor words below the line. *Using the anchor words as reference points, draw a short vertical line across the long horizontal line under each statement to show how you feel or rate yourself with regard to the situation described. Your first response is usually the best one.*

The following are two examples demonstrating how to complete a visual analogue scale:

Example 1:

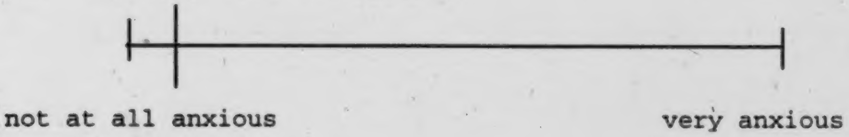
Not knowing the formula needed to solve a particular math problem.



In Example 1, the subject has displayed a high level of anxiety with regard to how s/he would feel about this situation.

Example 2:

Buying a math textbook.



In Example 2, the subject has rated this situation as causing very little anxiety.

Figure 3. Instructions for the SMACS-VAS and examples demonstrating the use of a visual analogue scale.

students felt anxious about statistics and the degree to which they felt anxious about mathematics anxiety. Scores were obtained for each item by measuring the distance, to the nearest millimetre, from the beginning of the scale (e.g. not at all anxious) to the point on the horizontal line at which the subjects drew a vertical line to represent how they rated their level of anxiety with regard to the situation described in the item stem. This process resulted in scores ranging from 0 to 101 for each of the 24 items. Subtest scores were equal to the mean of the item scores contained in each subtest. High scores indicated high levels of statistics anxiety and mathematics anxiety for each item and subtest.

Streiner and Norman (1992) reported that data obtained from a visual analogue scale and from a parallel Likert scale are frequently demonstrated to correlate substantially. They therefore cautioned that the advantage of the visual analogue scale may be "more perceived than real" (Streiner & Norman, 1992, p. 24). Consequently, results from the SMACS-VAS and the SMACS-5PT were compared to examine this potentiality. This comparison provided information as to whether different methods of assessment result in different outcomes with regard to statistics anxiety and mathematics anxiety.

State-Trait Anxiety Inventory

Spielberger's (1983) State-Trait Anxiety Inventory - Form Y (STAI) was used to assess levels of state anxiety and general anxiety, and is provided in Appendix C.[2] The STAI consists of 20 statements which assess how respondents feel currently (state) and 20 statements that evaluate how respondents typically feel (trait). For the state scale, respondents are asked to indicate the degree to which each of the statement reflects their feelings at the present time. A 4-point Likert scale is used for this purpose (1=not at all; 2=somewhat; 3=moderately so; 4=very much so). For the trait scale, respondents are asked to indicate the frequency with which the statements depict their typical or general feelings. Again, a 4-point Likert scale (1=almost never; 2=sometimes; 3=often; 4=almost always) is used.

Detailed information regarding the reliability and validity of the STAI (Form Y) is available in its corresponding manual (Spielberger, 1983). Spielberger (1983) noted that the transitory nature of state anxiety suggests that measures of internal consistency such as alpha coefficients would provide more meaningful reliability indices than test-retest correlations. Accordingly, alpha coefficients for S-Anxiety and T-Anxiety are provided. For an undergraduate college sample consisting of 531 females and 324 males the values were: S-Anxiety -- females = .93 (*M* = 38.76, *SD* = 11.95) and males = .91 (*M* = 36.47, *SD* = 10.02); T-Anxiety -- females = .91 (*M* = 40.40, *SD* = 10.15) and males = .90 (*M* = 38.30, *SD* = 9.18). The stability of the T-Anxiety scale was further demonstrated over a one hour test-retest interval using 109 female and 88 male undergraduate college students (*r* = .76 for females; *r* = .84 for males) and a 20 day test-retest interval with 75 female and 38 male undergraduate college students (*r* = .76 for females; *r* = .86 for males).

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[2] Permission to use this copyrighted instrument was obtained on June 12, 1996 from the author, Charles D. Spielberger.

Construct validity of the S-Anxiety scale was demonstrated by administering the scale to undergraduate university students (*N*=977) under high and low stress situations (Spielberger, Gorsuch, & Lushene, 1970). The students were asked to respond to the S-Anxiety scale according to how they generally felt under normal circumstances (normal condition), and then to respond to the scale again with regard to how they imagined they would feel just before taking a final examination in an important course (exam condition). The mean S-Anxiety scores were significantly higher in the exam condition than in the normal condition for both males and females; however the level of significance is not reported in the STAI manual. Additionally, the point-biserial correlations indicated that, for males and females, level of S-Anxiety was strongly associated with the exam condition; $\underline{r} = .60$ and $\underline{r} = .73$, respectively.

Evidence of the construct validity for the T-Anxiety scale was obtained by comparing the mean scores for neuropsychiatric patients classified as exhibiting depressive reaction ($\underline{N} = 28$), anxiety reaction ($\underline{N} = 60$), schizophrenia ($\underline{N} = 161$), brain damage ($\underline{N} = 31$), or character disorder ($\underline{N} = 22$) with the mean scores for working adults ($\underline{N} = 1838$), college students ($\underline{N} = 855$), high school students ($\underline{N} = 424$), and military recruits ($\underline{N} = 1964$). All but one of the neuropsychiatric groups (character disorder) displayed substantially higher T-Anxiety scores than the "normal" subjects. According to Spielberger, this finding "provides evidence that the STAI discriminates between normals and psychiatric patients for whom anxiety is a major symptom" (1983, p.14). He also noted that the absence of anxiety is viewed as a defining characteristic of individuals diagnosed with character disorder, therefore further contributing evidence to the construct validity of the STAI.

Correlations between the S-Anxiety scale and the T-

Anxiety scale depend upon the amount and type of stress associated with the conditions under which the S-Anxiety scale is administered (Spielberger, 1983). This finding supports the premise that state anxiety is typically of a transitory nature, while trait anxiety is relatively stable.

Background Questionnaire

The students were asked to complete a questionnaire designed to collect demographic information and information about their mathematics and statistics course backgrounds (see Appendix D). The background questionnaire provided demographic information such as gender, age, part-time or full-time student status, and program of study. Information regarding students' past experiences in statistics and mathematics such as whether they studied math throughout high school and enjoyed math at that time, the number of previous statistics courses and mathematics courses taken at both the undergraduate and graduate levels, degree of experience using computers, expected final grade in the current statistics course, whether the individual intends to take additional statistics courses and why, and future plans regarding type of employment desired after completion of degree was also collected.

Anxiety and Statistics Course Achievement

Permission was requested from the students and their instructors to receive the students' final grades in the statistics course in which they were currently enrolled. The relationship between anxiety and course performance has produced contradictory findings (Schwarzer, Seipp, & Schwarzer, 1989). Some studies have reported a negative or debilitating association, whereas others have found a positive or facilitating relationship. This discrepancy may be due to the degree or level of anxiety. Consequently, the procurement of students' final grades enabled examination of the relationship between statistics and mathematics anxiety, and course achievement.

Subjects

The population of interest in this study was graduate students in the social sciences who were enrolled in an introductory statistics course offered by departments of Educational Psychology and Nursing. The target groups, based on availability, were students from the University of Alberta and the University of British Columbia currently taking an introductory graduate level statistics course.

Samples

Students from two different statistics courses at the University of Alberta were included. One course was offered by the Educational Psychology Department (EdPsych 500) and the other was offered by the Nursing Department (Nursing 560). Examination of the course syllabi demonstrated that the two classes were comparable with regard to course content. These classes were held during the Fall term (September to December) of the 1996/97 academic year. At the University of British Columbia students from two sections of a statistics course offered by the Department of Educational Psychology and Special Education (EPSE 482 (1) and EPSE 482 (2)) were included. This course was similar in content to the courses taken by the University of Alberta students and was offered during the Winter term (January to early April) of the 1996/97 academic year.

Data Collection

Survey

Research in the area of statistics and mathematics anxiety has typically involved data collection near the beginning of the course (e.g. Benson & Bandalos, 1989; Plake & Parker, 1982; Schau, Stevens, Dauphinee, & Del Vecchio, 1995). An instructor of graduate level introductory statistics has observed that the anxiety level of students tends to be highest during the early stages of the course; the anxieties of most students diminish as the course progresses (J. A. Cameron, personal communication, April 29, 1996). However, some researchers (e.g. Schwarzer & Jerusalem, 1992; Spielberger, 1983) have demonstrated that, for some individuals, anxiety may be situation-specific and, therefore, that anxiety is not a static condition. Consequently, point in time may serve as a moderating factor for statistics anxiety. To investigate the effect of point in time, the survey data were collected at two different times during the course.

At the University of Alberta, the first data collection, Time 1, took place during the second and third week of classes for the fall term: September 12 to September 17, 1996. At the University of British Columbia, the initial data collection occurred during the second and third week of the winter term: January 14 to January 21, 1997. The second time or follow-up data collection, Time 2, was conducted near the end of the term at both universities: November 21 to December 1, 1996 at the University of Alberta, and on March 18, 1997 at the University of British Columbia. The time for follow-up data collection was chosen for two reasons. First, while students' anxiety levels often fluctuate throughout the course, anxieties typically abate as the course nears completion (J. A. Cameron, personal communication, April 29, 1996). Therefore, close to the end of the term would be the most fitting time to measure apparent change in anxiety. Second, collecting the follow-up data near the end of the term would take into account the fact that, while the course content of the introductory statistics courses at the University of British Columbia and the University of Alberta were similar, the order of presentation of this content was not the same. Consequently, factors such as dissimilar midterms and different assignments could become confounding variables if follow-up data were gathered mid-course. The order of the SMACS-5PT, the SMACS-VAS, and the STAI was counterbalanced to avoid possible confounding effects due to the order of presentation of these instruments. Additionally, the order of whether mathematics or statistics items were answered first in the SMACS-5PT and SMACS-VAS was randomly varied. Consequently, four conditions of administration of the instruments were developed:

(1) STAI, SMACS-VAS (math/stats), SMACS-5PT (math/stats);
(2) SMACS-5PT (stats/math), STAI, SMACS-VAS (stats/math);
(3) SMACS-VAS (math/stats), SMACS-5PT (stats/math), STAI;
(4) SMACS-5PT (stats/math), STAI, SMACS-VAS (math/stats).

Time 1

Based on the total number of students registered in each of the introductory statistics classes, individual packages, each containing the student consent form (see Appendix E), the SMACS-5PT, the SMACS-VAS, the STAI, ordered in one of the four sequences listed above, and the background questionnaire, were assembled. The consent form included a section asking students if they were willing to participate in a subsequent interview.

The surveys were administered by the researcher in the classroom during the last 20 minutes of class time. The researcher described the survey to the students, asked for their cooperation, and then administered the survey. The administration time was between 15 to 25 minutes.

Time 2

Follow-up data were collected by means of a second administration of the SMACS-5PT, SMACS-VAS, and STAI. As described previously, this administration took place near the end of the term. Comparable to the Time 1 data collection, the sequence in which the SMACS-5PT, SMACS-VAS and STAI were presented and the order of responding to mathematics or statistics items first was counterbalanced.

The instruments were administered by the researcher during the class period. Administration time was 15 to 20 minutes.

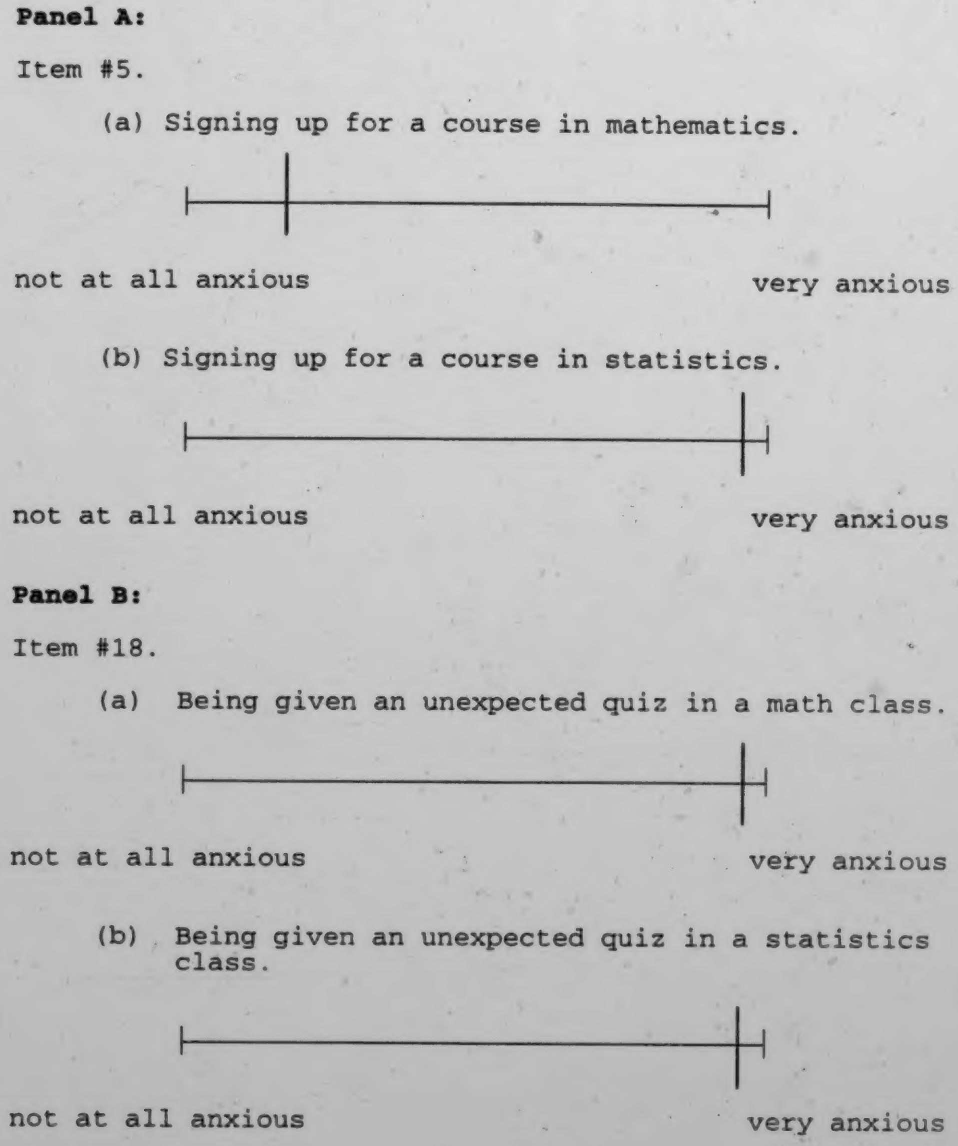
Interviews

The purpose of the interviews was to obtain more indepth information about how students felt with regard to statistics anxiety and mathematics anxiety. Four potential combinations of statistics and mathematics anxiety existed: statistics anxiety greater than mathematics anxiety, mathematics anxiety greater than statistics anxiety, equivalent statistics and mathematics anxiety, and neither statistics nor mathematics anxiety. The interviews would be most beneficial toward clarification between mathematics and statistics anxiety if representatives from each of these four groups were included.

However, as discussed in Chapter 5, it was not possible to select the interview sample in this way. For example, of the students who volunteered to be interviewed, no one was classified as having low statistics anxiety and high mathematics anxiety. Consequently, the selection criteria were modified. This modification was based on the results presented in the first part of Chapter 5. Therefore, a description of the selection criteria used, together with the findings of the interviews, is provided in the third part of Chapter 5.

The interviews were conducted as soon as possible after the Time 1 data collection and were semi-structured in format. Discussion of the participant's responses to some of the SMACS-VAS item pairs constituted part of the interview. For example, for situations in which they indicated they were more anxious in a mathematics setting than in a statistics setting, participants were asked to explain and elaborate possible reasons (see Panel A, Figure 4). Additionally, participants were also asked to explain why they felt equally anxious in other settings (either low anxiety or high anxiety for both settings) (see Panel B, Figure 4).

The students were then asked whether they preferred one response format to the other (e.g. visual analogue scale versus Likert scale). They were also asked about past experiences regarding mathematics and statistics and whether these factors had any effect on their responses to the statements. Finally, they were asked whether they considered themselves to be statistics-anxious or mathematics-anxious, and what, if any, differences they believed existed between the two types of anxiety. A copy of the semi-structured interview schedule is provided in Appendix F.



Panel A:

Item #5.

(a) Signing up for a course in mathematics.

not at all anxious
very anxious

(b) Signing up for a course in statistics.

not at all anxious
very anxious

Panel B:

Item #18.

(a) Being given an unexpected quiz in a math class.

not at all anxious
very anxious

(b) Being given an unexpected quiz in a statistics class.

not at all anxious
very anxious

Figure 4. Examples of responses to the statistics and mathematics items of the SMACS-VAS.

The interviews were conducted in a private room, lasted approximately 30 minutes, and were audio-taped for later transcription. The transcriptions were then summarized to provide a profile of each interview participant.

Data Preparation

Survey

Scores from each of the 24 items in the SMACS-VAS were obtained by measuring the distance, to the nearest millimetre, from the beginning of the scale to the vertical line made by subjects. In cases were students made a vertical line which was between two of the notches on the millimetre gauge, the lower millimetre value was recorded. The 92 student participants at Time 1 and 62 students at Time 2 resulted in a total of 7296 individual visual analogue scale items. A random sample of 111 items was selected and the responses were measured independently by a second individual. Agreement between the measurements made by the two individuals was 98.2%. Consequently, the initial set of measurements was considered to be accurate.

Responses to the STAI statements ranged from 1 to 4. For 10 of the S-Anxiety items and 11 of the T-Anxiety items a rating of 4 indicated the presence of a high level of anxiety. The remaining 10 S-Anxiety and 9 T-Anxiety items were worded so that a rating of 4 indicated the absence of anxiety. The ratings for these 19 items were reversed so that for all items a rating of 4 represented a high level of anxiety. Responses to the demographic questionnaire were quantitatively coded.

To ensure integrity of the questionnaire data, two individuals independently entered the responses to the SMACS-VAS, SMACS-5PT, STAI, and demographic questionnaire, collected at Time 1 and Time 2, into SPSS data files. The two files were then verified using the "match files" procedure in SPSS (version 6.1). This process merged the two data files and then, by means of a series of "do repeat-end repeat loops", enabled examination of any discrepancies in data entry. Altogether 1.7% inconsistencies were identified. The discrepancies between the two files were checked by returning to the original questionnaires, resolving the problem, and correcting the data files. This process was repeated until agreement was obtained between the two data files.

Analyses

Four major analyses were performed in this study. First, factor analyses were conducted to determine the factor structure of the statistics and mathematics anxiety data resulting from the visual analogue and Likert scales. Next, paired comparison t-tests were utilized to determine the difference between statistics and mathematics anxiety at the subtest level. Third, protocol analysis was employed to gain an understanding of these differences. Lastly, stepwise regression was conducted to assess the predictive nature of background variables with regard to statistics and mathematics anxiety. Given the sequential nature of these analyses, with the results from one step informing the analyses at the next step, the major analyses are provided together with the corresponding results in Chapters 4 and 5.

Preliminary Considerations

Four issues needed to be resolved before the main analyses of the data could be performed. The issues were (a) the nature of the sample, (b) the presence of missing data at the item level, (c) the presence of "intact groups", and (d) the potential of order effect. Each of these topics is discussed in order below.

Nature of the Sample

The sample of classes and, therefore, the sample of students were samples of convenience predetermined by location. Unsystematic factors such as the times at which the classes were offered and the fact that the statistics course was a program requirement dictated the nature of the students in each class. Consequently, the four classes were a collection of students rather than four deliberately formed, as in an experiment, groups.

Another consideration was that participation in this study was voluntary and not all students in the four classes chose to participate. Table 1 presents the total number of students in each class, the number of students who participated at each time of data collection, and the gender, mean age, and range of ages of these students. As shown, of the 34 students registered in the EdPsy 500 class, 32 participated at Time 1 and 29 students took part at Time 2. While all 17 of the students enrolled in Nursing 560 volunteered at Time 1, only two participated at Time 2. The absence of Nursing 560 volunteers at Time 2 was due to scheduling difficulties with the lecturer and, consequently with the students. Of the 26 students enrolled in EdPsy 482(1), 20 took part in Time 1 and 13 participated at Time 2, while 23 of the 28 students registered in EdPsy 482(2) participated at Time 1 and 18 participated at Time 2. Thus, from a total of 105 students in the four statistics classes, a sample of 92 volunteers was obtained at Time 1 and a

Table 1

Gender and Age of Student Volunteers

Time 1:

Class	n	Females	Males	Mean Age in Years	Age Range in Years
Nursing 560	17	14	3	37.59(9.25)	23 - 49
EdPsy 500	32	24	8	34.03(9.34)	21 - 59
EdPsy 482(1)	20	15	5	37.16(7.60)	25 - 52
EdPsy 482(2)	23	16	7	33.57(8.82)	20 - 52
Total	92	69	23	35.24(8.87)	20 - 59

Time 2:

Class	n	Females	Males	Mean Age in Years	Age Range in Years
Nursing 560	2	2	-	34.50(13.44)	25 - 44
EdPsy 500	29	21	8	33.68 (9.08)	21 - 59
EdPsy 482(1)	13	11	2	37.58 (8.39)	25 - 52
EdPsy 482(2)	18	12	6	34.22 (7.60)	23 - 59
Total	62	44	16	34.65 (8.53)	21 - 59

Note. Standard deviations are in parentheses.

sample of 62 volunteers was obtained at Time 2. The majority of students in each of the classes were female. Consequently the majority of the student volunteers were female. The mean ages across the classes and the times varied between 34 and 38 years. The ages of the students ranged from 20 to 59 years at Time 1 and 21 to 59 years at Time 2.

Missing Data

Examination of the responses of the 92 students who participated at Time 1 across the full set of instruments revealed that seven students did not respond to one item, one student omitted four items, and one student failed to respond to five items. At Time 2, five students did not respond to one item and one student omitted seven items. To avoid reduction of the sample size, and following Spielberger (1983), mean scores based on the remaining items for each of the statistics and mathematics anxiety measures were calculated and then imputed for the corresponding missing values for each of these students.

Intact Groups

Examination of the mean scores for statistics and mathematics anxiety revealed class differences, as shown in Table 2. Finn (1974) suggests that a data set which contains distinct groups of observations cannot be treated as a single group and recommends that the pooled within-group variance-covariance matrix be used in multivariate analyses (p. 82). To assess the need for this precaution factor analyses were conducted on the data from the statistics anxiety visual analogue scale, first using the total group correlations and second with the pooled within group correlations. The first two eigenvalues resulting from each analysis were comparable: 16.64 and 1.77 for the total group correlations and 16.52 and 1.65 for the pooled within group correlation. Given this finding, and the volunteer nature of the sample, class was disregarded in the subsequent analyses.

Order Effects

To test for effects, the administration of the SMACS-5PT, the SMACS-VAS, and the STAI was counterbalanced, at Time 1 and Time 2, to provide four conditions of administration. The number of students in each of the four conditions at Time 1 was n = 25, n = 22, n = 25, and n = 20,

Table 2

Means and Standard Deviations of Statistics and Mathematics Anxiety by Class

	Visual Analogue Scale		Likert Scale	
Class	Statistics	Mathematics	Statistics	Mathematics
Nursing 560	35.06 (19.42)	40.51 (21.78)	2.24 (0.87)	2.38 (0.86)
EdPsy 500	34.21 (23.42)	32.10 (22.46)	2.27 (0.72)	2.16 (0.80)
EdPsy 482(1)	52.58 (20.68)	43.22 (15.86)	2.74 (0.72)	2.48 (0.71)
EdPsy 482(2)	44.26 (27.19)	43.01 (28.46)	2.51 (0.87)	2.53 (1.11)

Note. Standard deviations are in parentheses.

respectively. At Time 2, the number of students in each of the four conditions was $n = 16$, $n = 14$, $n = 15$, and $n = 16$, respectively.

Two MANOVAs were conducted, one each at Time 1 and Time 2, to examine differences in statistics and mathematics anxiety, and state and trait anxiety, due to order. The dependent variables in this analysis were statistics and mathematics anxiety as measured by the visual analogue and the Likert scales, and state and trait anxiety as measured by the STAI. No significant differences in anxiety were found, at Time 1 and Time 2, due to the administration order (Time 1: $F = .760$, $df = 18, 232.416$, $p = .746$; Time 2: $F = .736$, $df = 18, 152.00$, $p = .769$). Given these findings, the samples were combined at each occasion of data collection.

In summary, the issues of missing data, intact groups, and order of presentation effect were addressed and resolved. The voluntary nature of the sample implies that the results be generalized with caution. The main analyses were performed on a complete data set, disregarding class and administration condition. The next chapter presents the analyses, and corresponding results, utilized to compare the responses obtained from the visual analogue scale and the Likert scale, with regard to statistics and mathematics anxiety.

CHAPTER IV: COMPARISON OF RESPONSE FORMATS

The analyses used to compare the Likert scale and visual analogue scale measurement strategies employed to assess statistics anxiety and mathematics anxiety are described in this chapter. Since the results of the analyses at one step informed the analyses at the next step, the results are presented and discussed with the analyses performed.

Each student responded to both the 24 statistics items and the 24 mathematics items using both the Likert scale and the visual analogue scale so that comparisons could be made to determine whether degree of statistics anxiety and mathematics anxiety was relatively the same regardless of the response format used. That is, before examining differences between statistics and mathematics anxiety, differences between response formats were investigated at the item, subtest, and total test levels.

Behaviour of the Items

Responses to the Likert scale and the visual analogue scale were first examined at the item level by way of means, standard deviations, and item-to-total score correlations for each item in each response format. This information is presented in Table 3 for the statistics anxiety items and Table 4 for the mathematics anxiety items. The items in each Table are sorted in ascending order according to the means of the Likert scale items. Table 5 provides the correlations between the responses to each Likert scale item and the responses to the corresponding visual analogue scale item for statistics and for mathematics anxiety. The items in Table 5 are sorted in ascending order according to the value of the correlation coefficient between each statistics anxiety Likert and visual analogue scale item.

Examination of the means for each item within statistics and mathematics suggested that the items were performing comparably between the two response formats. For example, larger means for Likert scale items were consistent with larger means for the corresponding visual analogue items. This can be seen in Figure 5 for statistics, and Figure 6 for mathematics. The graphs demonstrate that a positive linear relationship exists between the Likert item means and the parallel visual analogue item means; high scores on one scale correspond to high scores on the other scale. Additionally, comparison of the item-total score correlations for the Likert scale and the corresponding correlations for the visual analogue scale indicated that

Table 3

Means, Standard Deviations, and Item-to-Total Score Correlations for Likert and Visual Analogue Scale Statistics Anxiety Items

	Likert Scale		Visual Analogue Scale	
Item No.	Mean	Item-Total Correlations	Mean	Item-Total Correlations
2	1.67 (0.94)	.47	24.97 (27.55)	.67
8	1.73 (0.89)	.69	26.80 (27.17)	.81
16	1.76 (0.92)	.72	26.35 (28.87)	.80
20	1.84 (0.89)	.77	28.73 (26.63)	.87
13	1.86 (0.88)	.72	29.00 (26.70)	.82
11	1.87 (0.93)	.79	30.00 (28.29)	.90
1	1.95 (0.98)	.78	29.64 (27.49)	.80
10	1.98 (1.01)	.75	32.01 (28.48)	.84
14	2.08 (0.99)	.81	32.60 (27.53)	.87
5	2.09 (1.13)	.73	31.10 (30.33)	.82
22	2.12 (1.10)	.77	35.64 (30.41)	.85
4	2.26 (1.06)	.73	38.75 (30.15)	.84
23	2.30 (1.14)	.82	37.24 (30.52)	.85
9	2.36 (1.05)	.80	39.62 (29.97)	.89
7	2.40 (1.06)	.65	38.49 (28.89)	.86
19	2.46 (1.15)	.83	39.16 (30.75)	.90
17	2.67 (1.21)	.73	44.02 (30.90)	.83
15	2.72 (1.24)	.79	50.48 (30.89)	.86
21	2.91 (1.19)	.61	51.32 (31.51)	.65
3	3.07 (1.12)	.67	55.73 (31.07)	.73
6	3.25 (1.05)	.84	60.84 (28.78)	.84
12	3.37 (1.11)	.75	60.54 (27.88)	.79
18	3.70 (1.09)	.68	67.53 (26.94)	.71
24	3.86 (1.00)	.76	69.96 (26.24)	.74

Note. Values enclosed in parentheses represent standard deviations. _N_ = 92.

Table 4

Means, Standard Deviations, and Item-to-Total Score Correlations for Likert and Visual Analogue Scale Mathematics Anxiety Items

	Likert Scale		Visual Analogue Scale	
Item No.	Mean	Item-Total Correlations	Mean	Item-Total Correlations
16	1.58 (0.99)	.67	17.89 (21.67)	.71
2	1.75 (1.08)	.59	21.93 (26.34)	.68
8	1.75 (0.94)	.73	29.43 (27.79)	.84
20	1.83 (0.93)	.83	28.59 (26.33)	.85
11	1.85 (0.96)	.83	27.98 (26.38)	.85
10	1.95 (0.99)	.81	32.57 (28.14)	.86
13	1.95 (1.05)	.73	25.66 (24.30)	.74
1	1.98 (1.12)	.84	27.22 (26.94)	.75
17	1.99 (1.15)	.70	31.52 (28.51)	.76
14	2.09 (1.04)	.87	31.99 (28.22)	.88
5	2.11 (1.16)	.82	34.37 (30.21)	.81
22	2.16 (1.25)	.80	32.70 (30.12)	.85
9	2.23 (1.10)	.88	36.60 (29.61)	.89
7	2.26 (1.09)	.77	39.61 (27.51)	.82
23	2.33 (1.14)	.81	38.76 (32.12)	.87
19	2.33 (1.20)	.89	36.18 (28.83)	.87
4	2.33 (1.21)	.82	35.97 (27.65)	.79
15	2.67 (1.20)	.80	46.51 (31.46)	.79
21	2.95 (1.20)	.63	48.54 (30.59)	.58
3	3.02 (1.11)	.73	52.90 (27.84)	.75
12	3.21 (1.19)	.77	60.47 (29.55)	.83
6	3.27 (1.15)	.85	60.32 (29.02)	.84
18	3.48 (1.20)	.70	64.41 (30.07)	.76
24	3.71 (1.07)	.73	69.00 (26.43)	.77

Note. Values enclosed in parentheses represent standard deviations. N = 92.

Table 5

Item Correlations Between Response Formats for Statistics and Mathematics Anxiety

	Statistics Items	Mathematics Items
Item No.	Correlation Between Likert Scale and VAS	Correlation Between Likert Scale and VAS
3	.67	.77
12	.70	.79
14	.70	.85
7	.71	.77
10	.72	.77
13	.73	.73
5	.76	.72
11	.76	.76
20	.76	.79
1	.77	.67
6	.77	.80
4	.78	.75
16	.78	.63
23	.79	.83
2	.80	.77
8	.80	.62
24	.80	.81
17	.81	.67
19	.81	.80
15	.82	.77
18	.82	.82
21	.82	.86
22	.82	.80
9	.83	.80

Note. N = 92.

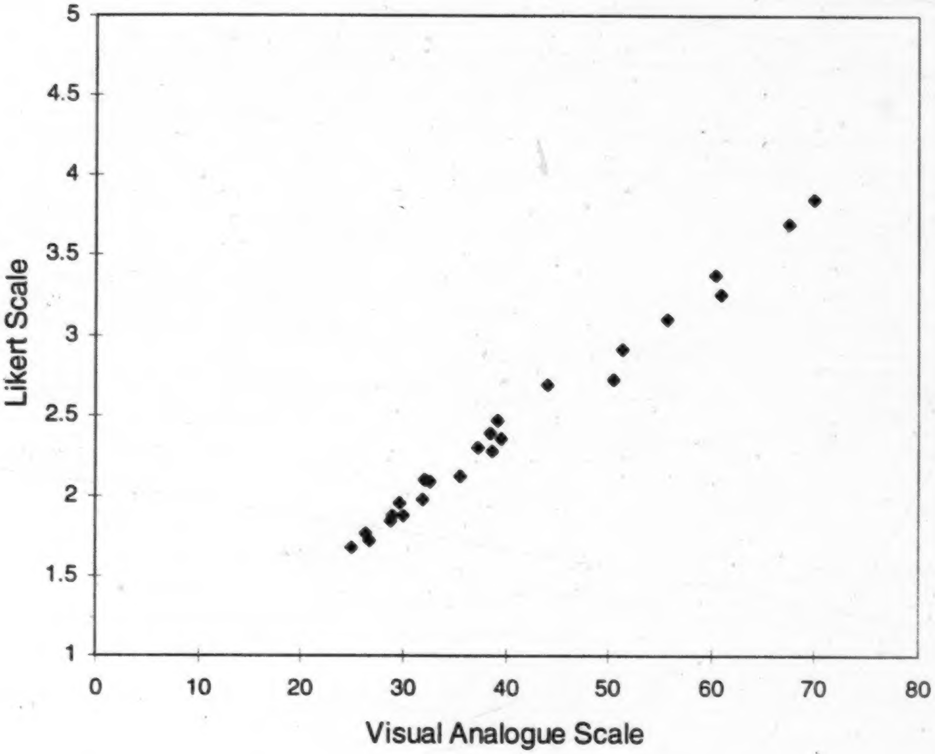


Figure 5. Plot of the statistics anxiety item means.

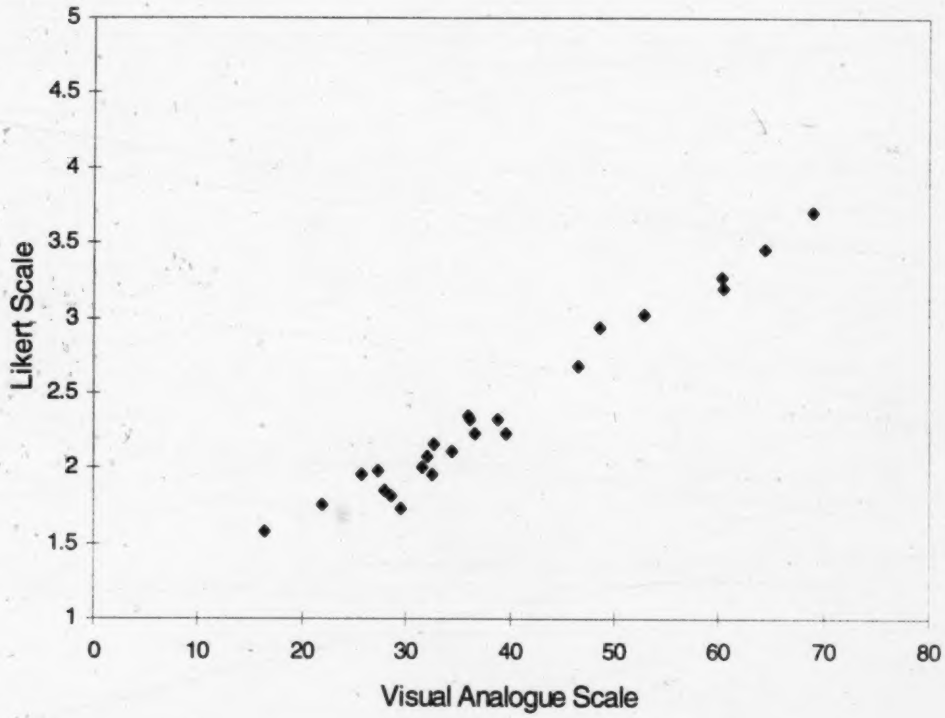


Figure 6. Plot of the mathematics anxiety item means.

the items were performing in a similar manner between the response formats, for statistics and mathematics (see Table 3 and Table 4, respectively). For example, items 2 and 21 provided the lowest item-total correlations for both response formats in both subject areas. The statistics item to total correlation coefficients ranged from .47 to .84 for the Likert scale and .65 to .90 for the visual analogue scale, while the mathematics items displayed coefficients ranging from .59 to .89 for the Likert scale and .58 to .89 for the visual analogue scale. Most of the item-total correlation coefficients were slightly lower for each of the Likert scale items due to the confined range of values and, consequently, the limited amount of variability for this format in comparison to the visual analogue scale.

Further evidence of the similarity of the behaviour of the items between the two response formats was provided by the correlations between each Likert scale item and the same item from the visual analogue scale (see Table 5). The correlations range from .67 to .83 for the statistics items and .62 to .86 for the mathematics items. These coefficients indicate moderately strong to strong linear relationships between the responses to the Likert items and the responses to the visual analogue items (Glass & Stanley, 1970, p. 117), further supporting the view that response patterns were similar regardless of the response format used.

To further clarify the comparability of the two measurement procedures at the item level, factor analyses were conducted. If the two response formats were performing in the same way, the corresponding items in each format should "load" on the same factor.

Confirmatory Factor Analysis

Given that Plake and Parker (1982) had earlier found a two factor orthogonal solution when they used the Likert format, a confirmatory factor analysis was performed, using Lisrel 8 (Jöreskog & Sörbom, 1996), on both the Likert format and the visual analogue format. The target matrix, or matrix to be fitted, was the factor matrix provided by Plake and Parker (1982, p. 553).

To assess the goodness of fit, the recommendations of Gierl and Mulvenon (1995) were followed. Three indices were utilized:

- the χ^2 statistic;
- the Root Mean Square Error of Approximation (RMSEA); and
- the Root Mean Square Residual (RMR).

The chi-square measures the distance between the sample covariance matrix and the fitted covariance matrix. Jöreskog states that the chi-square should be interpreted as a goodness-of-fit measure rather than a test statistic because large χ^2-values represent a bad fit while small χ^2-values indicate a good fit (1993, p. 308). The Root Mean Square Error of Approximation provides a measure of "the discrepancy per degree of freedom for the model" (Browne & Cudek, 1993, p. 144). As such, this assessment of fit encourages parsimony of the model. Browne and Cudek (1993) reported that a RMSEA value of 0.08 or less would indicate a reasonable error of approximation and therefore a good fit. The Root Mean Square Residual is a measure of the average of the fitted residuals (Jöreskog & Sörbom, 1996); a small RMR, 0.05 or less, indicates good model fit (Gierl & Rogers, 1996).

The goodness of fit indices resulting from the confirmatory factor analyses are presented in Table 6. Assessment of the fit indices indicated that the data resulting from each response format, within each subject area, failed to conform to the two factor orthogonal structure advanced by Plake and Parker (1982).

Table 6

Goodness of Fit Indices

	Goodness of Fit Statistics		
	χ^2	RMSEA	RMR
Statistics Anxiety			
Likert Scale	$\chi^2=495.04$ df=251 $p<.0001$	0.10	0.07
Visual Analogue Scale	$\chi^2=747.98$ df=251 $p<.0001$	0.15	59.73
Mathematics Anxiety			
Likert Scale	$\chi^2=542.94$ df=251 $p<.0001$	0.11	0.08
Visual Analogue Scale	$\chi^2=689.89$ df=251 $p<.0001$	0.14	65.27

Exploratory Factor Analysis of Statistics Anxiety Data

Consequently, exploratory factor analytic techniques were employed in an attempt to identify the underlying structure of the data resulting from the Likert and the visual analogue scales. If the items on the two scales were performing in the same way, then they should load on the same factors extracted in the same way. To facilitate the reporting of the exploratory factor analyses, the analyses and results for statistics anxiety are presented first, followed by the analyses and results for mathematics anxiety.

The factor analyses were completed in two stages. At the first stage, initial estimates of the number of factors were obtained. At stage two, the factors identified at stage one were rotated and transformed in an attempt to obtain interpretable solutions with good simple structure.

Statistics Anxiety Data

Stage 1: Determining the Initial Estimates of the Number of Factors

To determine the number of factors for the Likert scale and the visual analogue scale when measuring statistics anxiety, the following "rules" were used. First, using the results of a principal components analysis, the Kaiser-

Guttman rule (Kaiser, 1960) indicated three factors for the Likert scale and two factors for the visual analogue scale and the scree plots (Cattell, 1966) suggested two or three factors for both response formats. The maximum likelihood procedure (Lawley as cited in Gorsuch, 1983) revealed five factors for the Likert scale and 11 factors for the visual analogue scale. Lastly, Kaiser's image analysis followed by varimax rotation (Kaiser as cited in Comrey & Lee, 1992) disclosed three factors for each of the response formats. Consequently, with the exception of maximum likelihood, the number of factors underlying the statistics anxiety data for the two response formats appeared to be either two or three.

Stage 2: Derived Solutions

To decide between two and three factors several derived factor solutions were examined. The factor extraction used in each case was principal-axis factor analysis with squared multiple correlation as the initial communality estimates. The extracted factors were then rotated and transformed to obtain interpretable simple structure.

Orthogonal derived solutions.

Parallel to Plake and Parker's analysis, the two factor and the three factor derived solutions were first rotated orthogonally by means of varimax (Kaiser as cited in Gorsuch, 1983) using SPSS for

Windows, Release 6.1. Varimax rotations for the two factor and three factor solutions were unsatisfactory using Plake and Parker's (1982) criterion for a salient orthogonal factor loading of at least |.50|. The two factor solution for the Likert data resulted in five items with salient loadings on both factors (see Appendix G). With regard to the three factor solution, four items demonstrated a complexity of two, while two items did not load significantly on any of the factors (see Appendix H). The two factor solution for the visual analogue data resulted in six items with complexity two; three items demonstrated complexity two for the three factor solution (see Appendices H and I). Consequently, the notion of a final two factor or three factor orthogonal solution for the statistics anxiety data, as measured by the Likert and visual analogue scales, was abandoned.

Oblique derived solutions. The two and three factor solutions were next transformed using the oblimin procedure (Jennrich & Sampson, as cited in Gorsuch, 1983) in SPSS for Windows, Release 6.1. The obliquity index, δ, was varied from zero to -.5 by increments of .1 in an attempt to find the solutions with the best simple structure and for which the intercorrelations among the factors suggested distinct, albeit correlated factors. For both the Likert and the visual analogue scales, with loadings of at least |.4| defining salience, δ = -.1 provided the best two factor solution and δ = 0 provided the best three factor solution.

Comparison of the oblique two factor solutions for the likert and the visual analogue scales. The pattern loadings and factor correlation matrices for the two factor solutions of the Likert and the visual analogue scales are reported in Table 7. Examination of Factor II for both of the formats revealed that the majority of the pattern coefficients for the Likert scale were negative while the majority of the pattern coefficients were positive for the visual analogue scale. Therefore, the direction of Factor II for the visual analogue data was reflected to parallel the direction of the second factor for the Likert data (Harman, 1976, p. 29). Two double loadings were found for the two factor solution from the Likert data, while the visual analogue data resulted in simple structure.

Two different measures were used to determine the degree of congruence between the two-factor patterns. The first was the root-mean-square-deviation (RMS_k) given by the formula:

$$(s_1 - s_2)\,RMS_k = \sqrt{\frac{\sum_{j=1}^{v} ({}_{s1}a_{jk} - {}_{s2}a_{jk})^2}{v}},$$

Table 7

Oblique Two-Factor Solutions for the Statistics Anxiety Likert Scale and Visual Analogue Scale: Pattern Coefficients

	Likert Scale		Visual Analogue Scale	
	Factor I	Factor II	Factor I	Factor II
Item No.				
8	.85	.11	1.01	.17
16	.85	.06	.89	.05
13	.85	.07	.91	.05
10	.76	-.05	.83	-.06
11	.74	-.12	.89	-.06
5	.71	-.09	.80	-.07
1	.70	-.15	.79	-.05
20	.67	-.17	.90	-.01
2	.64	.14	.79	.10
23	.62	-.27	.62	-.30
14	.61	-.28	.79	-.13
22	.60	-.25	.58	-.34
4	.53	-.27	.60	-.31
7	.50	-.22	.78	-.14
19	.49	-.43	.79	-.17
9	.47	-.42	.64	-.33
12	-.08	-.97	.05	-.87
24	-.03	-.90	-.08	-.96
6	.15	-.82	.12	-.85
18	.03	-.75	.01	-.83
17	.26	-.57	.36	-.56
21	.13	-.56	.24	-.49
3	.21	-.56	.21	-.62
15	.38	-.50	.35	-.61

Factor Correlation Matrix

Likert Scale

	I	II
I	1.00	
II	-.67	1.00

Visual Analogue Scale

	I	II
I	1.00	
II	-.70	1.00

where ${}_{(s1\,-\,s2)}RMS_k$ is the root-mean-square deviation for factor k and samples s_1 and s_2, v is the number of variables, and ${}_{s1}a_{jk}$ and ${}_{s2}a_{jk}$ are, respectively, the factor coefficients for samples s_1 and s_2. This statistic provides a measure of the consensus in magnitude of the corresponding pattern coefficients from two different solutions; it imposes rigorous similarity requirements on comparisons of factors because it measures *any* deviation between the two factors (Rummel, 1970, p. 461). If the RMS_k is at or near zero, the factor solutions are similar in direction and magnitude. Conversely, as the statistic shifts from zero, the factors are increasingly dissimilar. This coefficient may be viewed as a measure of absolute fit between two factor solutions.

The value of the RMS_1 for Factor I was .13 and the value of the RMS_2 for Factor II was .09. Both values are close to zero indicating a high degree of similarity, with regard to size and direction of the loadings, between the factor patterns for each response format.

The second measure employed to compare the factors of each response format was the coefficient of congruence (Tucker, as cited in Harman, 1976, p. 343). The formula is as follows:

$$s_1, s_2\Phi_k = \frac{\sum_{j=1}^{v} {}_{s1}a_{jk} * {}_{s2}a_{jk}}{\sqrt{\sum_{j=1}^{v} {}_{s1}a^2_{jk} * \sum_{j=1}^{v} {}_{s2}a^2_{jk}}},$$

This statistic is similar to a correlation coefficient in that a coefficient of congruence of -1.00 represents perfect negative similarity, zero indicates complete dissimilarity, and +1.00 represents perfect similarity (Rummel, 1970, p. 461). Mulaik (1972, p. 355) reports that although there is no statistical test associated with the coefficient of congruence, it is common to accept 2 factors as equivalent if the index is .90 or greater.

The coefficient of congruence for Factor I was .99; the coefficient for Factor II was .98. These values indicate that near perfect positive relationships exist between the two sets of pattern coefficients for both Factor I and Factor II. Following Mulaik and the findings of the root-mean-square-deviations, it was concluded that the two-factor solutions were equivalent.

Comparison of the oblique three factor solutions for the likert and the visual analogue scales. The pattern for the three factor solutions of the Likert and visual analogue scale (see Appendix I for loadings and factor correlation matrices) revealed that the two solutions were quite different, in contrast to the findings for the two-factor, oblique solutions. Similar to the reflection procedure applied to the visual analogue two-factor solution, the direction of the second and third factors of the visual analogue data was reflected to parallel the direction of the second and third factors for the Likert data.

The RMSs for Factors I, II, and III were .47, .10, and .43, respectively. The coefficients of congruence were, respectively .50, .98, and .26. Together, the values of these measures demonstrate that the second factor of each response format is most similar with regard to size and direction of the pattern coefficients; the first factor and the third factor of the Likert and visual analogue scales display considerably less similarity. Furthermore, the three factor solutions did not lead to improved simple structure and the factors were not clearly interpretable. The second factor for the visual analogue data was identical to the second factor for the Likert data and was interpretable (evaluation anxiety). However, while the third factor for the Likert format was interpretable (readiness or preparation), the third factor for the visual analogue scale was not interpretable, nor was the newly constructed Factor I for both formats. The failure to be able to interpret Factors I and III parallels the numerical findings using the root-mean-square-deviations and the coefficients of congruence. It appears that a three-factor solution results in over-factoring; in this case, the two response formats yielded inconsistent and uninterpretable results. Seemingly the choice of which of the two response formats to use is inconsequential when the correct factor solution is obtained.

Mathematics Anxiety Data

Stage 1: Determining the Initial Estimates of the Number of Factors

The same procedure used to determine the number of factors for the two response formats for statistics anxiety was followed to determine the number of factors for the two response formats for mathematics anxiety. Using the results of a principal components analysis, the Kaiser-Guttman rule indicated three factors for the Likert scale and two factors for the visual analogue scale, while the scree plots suggested two or three factors for both response formats. Maximum likelihood analysis indicated six factors for each of the formats and, lastly, Kaiser's image analysis followed by varimax rotation suggested three or four factors for both formats. Consequently, with the exception of maximum likelihood, the extraction procedures indicated that the number of factors underlying the mathematics anxiety data for the two response formats was two to four factors.

Stage 2: Derived Solutions

Several derived solutions were examined to decide between two, three, and four factor solutions. The factor extraction was conducted using principal-axis factor analysis with squared multiple correlations as the initial communality estimates. The extracted factors were subsequently rotated and transformed to obtain simple structure which was interpretable.

Orthogonal derived solutions. The two, three, and four factor solutions were rotated orthogonally using varimax. Using Plake and Parker's (1982) criterion of at least $|.5|$ for a salient factor loading, the two, three, and four factor solutions were unsatisfactory. The two factor solution for the Likert data resulted in six items with salient loadings on both factors (see Appendix J). For the three factor solution, eight items from the Likert data demonstrated complexity of two (see Appendix K). The two factor solution for the visual analogue data resulted in six items with complexity two; four items were found to have complexity two for the three factor solution (see Appendices J and K). In the case of four factors, a fourth factor did not exist for either of the formats. Consequently, it was concluded that all of the orthogonal solutions were unsatisfactory for both response formats. Further, given the failure of obtaining a four factor solution, the notion of four factors was abandoned.

Oblique derived solutions. The two and three factor solutions were subsequently transformed using the oblimin procedure. The obliquity index, δ, was varied from zero to -.5 by increments of .1 in an effort to obtain the best simple structure for each response format. The best two factor solution for both the Likert and the visual analogue data was provided by δ = -.1, while δ = 0 produced the best three factor solutions for both scales. Loadings of at least |.4| were defined as representing salience for the two and three factor oblique solutions of both response formats.

Comparison of the oblique two factor solutions for the likert and the visual analogue scales. The pattern loadings and factor correlation matrices for the two factor solutions of the Likert and visual analogue scales are reported in Table 8. One double loading was found for the two factor solution from both the Likert and the visual analogue data. The solutions were parallel between the two response formats in that the same items loaded on the same factors. The RMSs for Factor I and Factor II were .11 and .11, respectively. The coefficients of congruence were, respectively, .99 and .98. These measures of congruence indicate that a nearly perfect association exists between the two sets of pattern coefficients for Factor I and Factor II. It was therefore concluded that the two-factor solutions for the Likert data and the visual analogue data were equivalent.

Table 8

Oblique Two-Factor Solutions for the Mathematics Anxiety Likert Scale and Visual Analogue Scale: Pattern Coefficients

	Likert Scale		Visual Analogue Scale	
	Factor I	Factor II	Factor I	Factor II
Item No.				
20	.94	-.09	.92	-.02
8	.91	-.18	.97	-.09
1	.89	-.02	.72	.07
5	.87	-.02	.67	.19
10	.85	-.00	.94	-.03
11	.83	.04	.91	-.01
14	.81	.11	.78	.15
19	.79	.16	.74	.20
22	.75	.10	.78	.12
16	.75	-.05	.85	-.12
9	.75	.19	.65	.31
23	.74	.12	.71	.22
4	.71	.17	.54	.31
13	.70	.07	.85	-.07
2	.66	-.05	.78	-.07
7	.58	.27	.62	.27
17	.45	.32	.43	.40
24	-.03	.94	.00	.90
12	.02	.92	.01	.97
18	.10	.73	.03	.86
6	.37	.60	.09	.88
21	.20	.53	.07	.59
15	.37	.53	.33	.56
3	.39	.42	.27	.57

Factor Correlation Matrix

Likert Scale

	I	II
I	1.00	
II	.68	1.00

Visual Analogue Scale

	I	II
I	1.00	
II	.70	1.00

Comparison of the oblique three factor solutions for the likert and the visual analogue scales. Contrary to the findings for the two-factor oblique solutions, the pattern for the three factor solutions of the Likert and visual analogue scale demonstrated that the two solutions were quite different (see Appendix L) for loadings and factor correlation matrices). The RMSs for Factors I, II, and II were .36, .19. and .56, respectively, while the coefficients of congruence were .80, .92, and -.09, respectively. The values of these measures indicate that the second factors of the formats are most similar, while the first and third factors of the Likert and visual analogue scales are markedly less similar.

The three-factor solutions did not provide improved simple structure and the factors were not clearly interpretable. The second factor for the visual analogue scale was comprised of two additional items compared to the second factor for the Likert scale. The third factor for the Likert scale was interpretable (readiness or preparation), however the third factor for the visual analogue scale and the newly constructed Factor I for both formats could not be interpreted. These findings parallel the values of the measures of congruence and further demonstrate that a three-factor solution, for both formats, produces inconsistent and uninterpretable results.

In summary, the two factor solution was considered preferable, with regard to simple structure and interpretability, for the Likert scale and the visual analogue scale in both statistics and mathematics. Furthermore, the measures of congruence comparing the Likert pattern coefficients with the visual analogue pattern coefficients demonstrated a high degree of similarity between the two factor solutions, for both subject areas. Therefore, it was concluded that the behaviour of the items did not differ between the two response formats once the correct factor solution was determined.

Behaviour of the Subtests

The results of the exploratory factor analyses conducted using the Likert and visual analogue scale items confirmed the existence of two subtests: course content anxiety and evaluation anxiety. The calculation of scores for individuals on each subtest or factor was considered as a means by which to obtain subtest scores. Morris (1979) reports that the regression estimates approach is most applicable for common factor analysis because an exact solution can not be computed due to the unknown matrix of uniqueness. Additionally Gorsuch (1983, p. 260) cautions that the calculation of factor scores for a common factor analysis is problematic because of the indeterminacy of the model, as such individuals' scores can only be estimated on the common factors, not uniquely.

Consequently, it was decided that individuals' observed scores for the items would be used to calculate subtest scores for both response formats and subject areas. The subtests resulting from the statistics items for both the Likert and the visual analogue scales will be discussed first, followed by the subtests which were comprised from the mathematics items according to the Likert and visual analogue scales.

Statistics Anxiety Subtests

The subtests for each of the response formats, based on the two-factor oblique solutions, consisted of the same items: the course content anxiety subtest was comprised of items 1, 2, 4, 5, 7, 8, 9, 10, 11, 13, 14, 16, 19, 20 22, and 23; the evaluation anxiety subtest was comprised of items 3, 6, 12, 15, 17, 18, 21, and 24. The means, standard deviations, reliability coefficients, and standard error of measurement are reported in Table 9 for both response formats.

The mean subtest scores for each response format behaved similarly in that the mean evaluation scores for the Likert scale and the visual analogue scale were substantially higher than the mean course content scores for each format. All of the subtests demonstrated high internal consistency, ranging from .93 to .98, as measured by Cronbach's α. Furthermore, each subtest resulting from the

Table 9

Means, Standard Deviations, Measures of Internal Consistency, and Standard Errors of Measurement for the Likert and Visual Analogue Scale Statistics Subtests

Subtest	Mean	N	k	Cronbach's ∝	SEM
Course Content Anxiety					
Likert	2.04 (0.79)	92	16	.96	0.16
Visual Analogue	32.57(25.01)	92	16	.98	3.54
Evaluation Anxiety					
Likert	3.20 (0.93)	92	8	.93	0.26
Visual Analogue	57.57(25.24)	92	8	.95	5.64

Note. Values enclosed in parentheses represent standard deviations. k = number of items.

Likert scale was highly correlated with the corresponding subtest from the visual analogue scale: $r = .91$ for course content and $r = .87$ for evaluation ($p < .0001$). Consequently, a substantial degree of similarity between the subtests of the two response formats was observed, providing further evidence of congruence between the Likert scale and the visual analogue scale.

Mathematics Anxiety Subtests

The subtests for the Likert scale and the visual analogue scale, based on the two-factor oblique solutions, were comprised of the same items with the exception of item 3. This item, "Being given a homework assignment of many difficult math problems which is due the next class meeting", loaded on Factor II for the visual analogue scale and Factor I for the Likert scale. However, examination of the pattern loadings for this item on the Likert scale demonstrated that item 3 was approaching salience for Factor II. Furthermore, the measures of congruence between the factor patterns for the Likert scale and the visual analogue scale indicated that the factors were very similar between the two response formats. Therefore, item 3 of the Likert scale was assigned to Factor II thus providing analogous subtests between the two formats.

The course content anxiety subtest for the Likert and visual analogue scales consisted of items 1, 2, 4, 5, 7, 8, 9, 10, 11, 13, 14, 16, 17, 19, 20, 22, and 23, and the evaluation anxiety subtest was comprised of items 3, 6, 12, 15, 18, 21, and 24. Means, standard deviations, reliability coefficients, and standard error of measurement for the subtest scores resulting from each response format are provided in Table 10.

The mean subtest scores for the Likert scale and the visual analogue scale were similar in that the mean evaluation scores for both response formats were considerably higher than the mean course content scores for each format. The measures of internal consistency for each of the subtests were high, ranging from .93 to .97. Comparison of the subtests between the two response formats indicated strong correlations: $r = .90$ between the course content subtests and between the evaluation subtests ($p < .0001$); accordingly, the mathematics subtests were very similar regardless of the format used.

Behaviour of the Total Tests

It is common to report total or composite test scores as determined from the subtest scores (Lord & Novick, 1968). Whereas the factor analyses clearly demonstrated that two subtests exist within both the statistics and mathematics items, total test scores were calculated based on the average of individuals' subtest scores, for both response

Table 10

Means, Standard Deviations, Measures of Internal Consistency, and Standard Errors of Measurement for the Likert and Visual Analogue Scale Mathematics Subtests

Subtest	Mean	N	k	Cronbach's α	SEM
Course Content Anxiety					
Likert	2.01 (0.88)	92	17	.97	0.15
Visual Analogue	30.80(23.36)	92	17	.97	4.05
Evaluation Anxiety					
Likert	3.19 (0.99)	92	7	.93	0.26
Visual Analogue	57.45(25.42)	92	7	.94	6.23

Note. Values enclosed in parentheses represent standard deviations. k = number of items.

formats. The total test scores are considered to represent general statistics anxiety and general mathematics anxiety. The means, standard deviations, reliability coefficients, and standard errors of measurement for the composite scores, for the Likert and the visual analogue scales were calculated for both subject areas and are presented in Table 11.

The composite nature of the total test scores led to the use of Cronbach's stratified alpha (α_s) to obtain a lower bound on the reliability (Lord & Novick, 1968, p. 87-91). The measures of reliability of the composites were high, ranging from .84 to .96. Furthermore, the total test scores between the two response formats, for statistics and mathematics, were highly correlated; the coefficients were .91 for statistics and .92 for mathematics ($p < .0001$). Therefore, as with the behaviour of the items and the behaviour of the subtests, the total test scores for each subject were very similar regardless of the format used.

Table 11

Means, Standard Deviations, Measures of Internal Consistency, and Standard Errors of Measurement for the Likert and Visual Analogue Scale Statistics and Mathematics Total Test Scores

Total Test Score	Mean	Cronbach's α_s	SEM
Statistics			
Likert	2.62 (0.82)	.96	0.16
Visual Analogue	45.07(23.93)	.90	7.57
Mathematics			
Likert	2.60 (0.89)	.84	0.36
Visual Analogue	44.12(23.11)	.88	8.00

Note. Values enclosed in parentheses represent standard deviations. $N = 92$.

Individual Preferences

Information regarding individual preferences for the Likert and the visual analogue scales was obtained through interviews; participants were asked whether they preferred responding to one format or the other. Of the 21 individuals interviewed, 47.6% preferred the visual analogue scale, 33.3% preferred the Likert scale, 9.5% had no preference, and 9.5% had no comment.

Individuals who preferred the Likert scale made the following comments: the Likert scale seemed "more accurate", "more clear", and "more concrete", while the visual analogue "seemed arbitrary","was hit and miss", and "was not meaningful". Individuals who stated a preference for the visual analogue scale offered the following reasons: the visual analogue scale was "more concrete", "more accurate", and "easier to express myself", while the Likert scale "is more abstract", "with the Likert often I'm in between two categories", and "it's too absolute (only 5 choices)".

In summary, the behaviour of the items with regard to the results of the oblique factor solutions, the root-mean-square-deviations, and the coefficients of congruence, as well as the behaviour of the subtests and the total tests led to the conclusion that, generally type of response format did not affect the assessment of statistics and mathematics anxiety. Consequently, it was decided that subsequent analyses would be conducted exclusively with data from one response format. The visual analogue scale was chosen for two reasons: first, it was anticipated that the increased range of values associated with these scales may facilitate investigation of differences between statistics and mathematics anxiety and second, items from the visual analogue scales were used during the interviews to promote discussion of similarities and differences of responses with regard to statistics and mathematics situations.

CHAPTER V: COMPARISON OF STATISTICS ANXIETY AND MATHEMATICS ANXIETY

The analyses used to compare statistics anxiety and mathematics anxiety and the results of these analyses are described and reported in this chapter. As was concluded in the previous chapter, type of response format did not affect the assessment of statistics and mathematics anxiety. Therefore, the following analyses were completed using only the data obtained from the visual analogue scales. Differences between statistics anxiety and mathematics anxiety were investigated at the subtest level.

An analysis-wise Type I error rate of .05 was used for each of the sets of analyses conducted. This error rate does not accommodate inflation of Type I error due to multiple tests but does control Type II error of erroneously finding no "difference" when there may have been. The risk of Type II error was viewed as the greater concern in this study. This approach provides a "more stringent" test of differences between statistics and mathematics anxiety.

Comparison and Interpretation of the Two Factor Oblique Solutions for Statistics and Mathematics Anxiety

A two factor oblique solution provided the best simple structure and interpretability for both statistics and mathematics anxiety (see Tables 7 and 8). The root-mean-square deviations between the two factor patterns were .08 for both Factor I and Factor II. The coefficients of congruence were .99 for Factor I and .98 for Factor II. These measures indicated an almost perfect association between the two sets of pattern coefficients for Factor I and Factor II. Furthermore the correlations between the factors for both solutions was .70. Based on these findings, it was concluded that the two-factor oblique solutions for statistics anxiety and for mathematics anxiety were equivalent.

Pattern loadings of at least |.4| were used to represent salient loadings in order to reflect the very high loadings of some of the items and to advance simple structure. This decision resulted in simple structure for the statistics anxiety data and one double loading (item 17) for the mathematics anxiety data. The same items loaded on each factor, for statistics and mathematics anxiety, with the exception of item 17. This item loaded on Factor II for statistics anxiety and, as mentioned, demonstrated a significant loading on both Factor I and Factor II for mathematics anxiety.

The mean for item 17 is higher for statistics anxiety than mathematics anxiety (see Tables 3 and 4). Item 17 is somewhat unique compared to the other items because it depicts different situations for statistics and mathematics, as shown in Table 12. The wording of the remaining statistics and mathematics anxiety items differ only in terms of the referent being used. Given the high degree of factor similarity between the pattern coefficients for statistics anxiety and mathematics anxiety, the decision was made to assign item 17 for mathematics anxiety to Factor II. Therefore, each of the factors or scales resulting from statistics anxiety and mathematics anxiety could be further compared. The items which constitute each factor are presented in Table 12.

The first factor was comprised of 16 items which involved anxiety about class related activities associated with studying statistics or mathematics. These activities included listening to a lecture, being told how to interpret probability statements, and reading formulas. Therefore, this factor or scale was labelled Course Content Anxiety.

The second factor consisted of eight items. These items involved anxiety about activities that pertained to

Table 12

Items Comprising the Statistics and Mathematics Anxiety Scales

Item No.	Course Content Anxiety Scale
16	Reading the word "Statistics (Mathematics)".
13	Walking on campus and thinking about a statistics (mathematics) course.
8	Walking into a statistics (mathematics) course.
10	Looking through the pages of a statistics (mathematics) text.
11	Starting a new chapter in a statistics (mathematics) book.
5	Signing up for a course in statistics (mathematics).
20	Listening to a lecture in a statistics (mathematics) class.
14	Picking up a statistics (mathematics) textbook to begin working on a homework assignment.
1	Watching a teacher work a statistical (mathematical) equation on the blackboard.
2	Buying a statistics (mathematics) textbook.
23	Being told how to interpret statistical (mathematical) probability statements.
22	Having to use the tables in the back of a statistics (mathematics) book.
4	Reading and interpreting graphs or charts in a statistics (mathematics) textbook.
19	Reading a formula in statistics (mathematics).
9	Solving a statistical (mathematical) problem.
7	Listening to another student explain a statistical (mathematical) formula.
	Evaluation Anxiety Scale
12	Taking an examination (quiz) in a statistics (mathematics) course.
24	Taking an examination (final) in a statistics (mathematics) course.
6	Thinking about an upcoming statistics (mathematics) test one day before.
18	Being given an unexpected quiz in a statistics (mathematics) class.
21	Waiting to get a statistics (mathematics) test returned in which you expected to do well.
17	Working on an abstract probability problem such as: If we have a 52-card deck and randomly chose one card, calculate the probability that card will be a heart or an ace. (Working on an abstract mathematical probability problem such as: If x=outstanding bills and y=total income, calculate how much money is left for recreational expenditures.)
15	Getting ready to study for a statistics (mathematics) test.
3	Being given a homework assignment of many difficult statistics (mathematics) problems which is due the next class meeting.

the assessment of students. These activities included taking an examination, getting ready to study for a test, and being given an assignment of many difficult problems. Thus, this scale was labelled Evaluation Anxiety.

Comparison of Statistics and Mathematics Anxiety Scales

Given the different number of items in the Course Content Anxiety Scale and the Evaluation Anxiety Scale, a student's observed score for each anxiety scale was set equal to his/her mean scale score:

$$\overline{X}_{js} = \frac{\sum_{i=1}^{k_s} X_{jis}}{k_s},$$

where X_{jis} is the observed score of student j on item i in scale s,

k_s is the number of items in scale s, and

$\overline{X}_{js}$ is the mean scale score for person j on scale s, s=1, 2.

A high mean scale score reflected a high level of anxiety, a low mean reflected a low anxiety level.

Time 1

The mean scale scores, standard deviations, internal consistencies (Cronbach's $\propto$), and the standard errors of measurement for the two anxiety scales are reported in Table 13 for statistics and mathematics. As shown, the internal consistency, Cronbach's alpha, is high for each scale at Time 1. The standard errors of measurement are less than 6. The difference between the mean of the course content anxiety scale for statistics and the mean of the course content anxiety scale for mathematics was not significant at Time 1 ($\underline{t}(91) = 1.02$, $\underline{p} = .31$). In contrast, the mean for statistics evaluation anxiety was significantly higher than the mean for mathematics evaluation anxiety ($\underline{t}(91) = 3.65$, $p < .01$). The corresponding effect size of the mean difference is equal to one standard deviation or 29.72 (Glass & Hopkins, 1984). The dispersions of both pairs of scales were not significantly different ($\underline{t}(90) = .99$ for course content anxiety; $\underline{t}(90) = .38$ for evaluation anxiety). Lastly, the correlations between the pairs of scores were .84, for course content anxiety, and .94 for evaluation anxiety. Taken together, these results for statistics and for mathematics indicate that (a) the levels and dispersions of course content anxiety are the same, (b) while the dispersion of evaluation anxiety is the same for both

Table 13

Means, Standard Deviations, Standard Error of Measurement, and Cronbach's α for the Statistics and Mathematics Anxiety Scales at Time One

Scales	M (SD)	k	SEM	Cronbach's α
Course Content Anxiety				
Statistics	32.57 (25.01)	16	3.54	.98
Mathematics	31.07 (23.63)	16	4.09	.97
Evaluation Anxiety				
Statistics	57.57 (25.21)	8	5.64	.95
Mathematics	54.21 (24.87)	8	5.56	.95

Note. *N* = 92.

subjects, the students possessed higher evaluation anxiety toward statistics than toward mathematics, and (c) the levels of both course content anxiety and evaluation anxiety toward statistics and toward mathematics are strongly related. Course content anxiety and evaluation anxiety were highly correlated for both statistics and mathematics ($\underline{r} = .81$, $\underline{p} < .05$).

Time 2

The mean scale scores, standard deviations, internal consistencies (Cronbach's α), and the standard errors of measurement for the two anxiety scales are reported in Table 14 for statistics and mathematics. Similar to Time 1, Cronbach's alpha is high for each scale at Time 2. The standard errors of measurement are less than 6. Likewise, the difference between the mean of the course content anxiety scale for statistics and the mean of the course content anxiety scale for mathematics was not significant at Time 2 ($\underline{t}(61) = -.90$, $\underline{p} = .37$); the dispersions were equal ($\underline{t}(60) = -.38$), and the correlation value between the scales was .82. Unlike the situation at Time 1 where the students' anxiety about evaluation in statistics was greater than their anxiety about evaluation in mathematics, the two

Table 14

Means, Standard Deviations, Standard Error of Measurement, and Cronbach's ∝ for the Statistics and Mathematics Anxiety Scales at Time Two

Scales	M (SD)	SEM	Cronbach's ∝
Course Content Anxiety			
Statistics	27.80 (24.25)	2.42	.99
Mathematics	28.93 (24.73)	2.47	.99
Evaluation Anxiety			
Statistics	53.30 (26.14)	5.84	.95
Mathematics	52.08 (26.20)	5.24	.96

Note. N = 62.

levels of evaluation anxiety did not differ at Time 2 (_t_(61) = 1.15, _p_ = .26). The dispersions were not significantly different (_t_(60) = -.06), and the correlation between the evaluation anxiety levels was .95. Thus, at Time 2, the levels of anxiety about course content and about evaluation were the same for both subjects. Similar to Time 1, there was a strong correlation between anxiety about course content and anxiety about evaluation for statistics, _r_ = .81, and for mathematics, _r_ = .85.

Stability of Statistics and Mathematics Anxiety Over Time

A comparison between the levels of anxiety at Time 1 and Time 2 was made for the subsample of students who were assessed at both times. Approximately nine to ten weeks separated the Time 1 and Time 2 data collections. The means, standard deviations, internal consistencies, and the standard error of measurement for this subsample at Time 1 are reported in Table 15 together with the corresponding correlations to Time 2. First, the correlations between the scales at Time 1 and Time 2 are test-retest reliabilities. The values, which range from .67 to .80, reflect moderately strong stability from Time 1 to Time 2. Therefore, students who demonstrated higher levels of anxiety at Time 1 tend to

Table 15

Means, Standard Deviations, Correlation with Time Two, Standard Error of Measurement, and Cronbach's ∝ for the Statistics and Mathematics Anxiety Scales for Subsample at Time One

Scales	M(SD)	$r_{Time1,\ Time2}$	SEM	Cronbach's ∝
Course Content Anxiety				
Statistics	31.78(24.31)	.67	3.44	.98
Mathematics	29.80(23.28)	.75	4.03	.97
Evaluation				
Statistics	57.51(25.78)	.73	5.76	.95
Mathematics	55.20(25.46)	.80	5.69	.95

Note. $N = 62$. Correlations are significant at $p < .01$.

exhibit higher levels of anxiety at Time 2. Further, comparisons of the mean differences between Time 1 (see Table 15) and Time 2 (see table 14) revealed no significant change ($\underline{t}(61) = 1.58$, $\underline{p} = .12$ for statistics course content anxiety; $\underline{t}(61) = 1.74$, $\underline{p} = .09$ for statistics evaluation anxiety; $\underline{t}(61) = .41$, $\underline{p} = .69$ for mathematics course content anxiety; and $\underline{t}(61) = 1.02$, $\underline{p} = .31$ for mathematics evaluation anxiety). The mean of the difference between Time 1 and Time 2, for each of the anxiety scales, was as follows (standard deviations of the differences are provided in parentheses): statistics course content anxiety = 3.98(19.85); statistics evaluation anxiety = 4.20(18.98); mathematics course content anxiety = 0.87(16.86); and mathematics evaluation anxiety = 2.12(16.31). The corresponding dispersions were equal for statistics course content anxiety ($\underline{t}(60) = .03$), statistics evaluation anxiety ($\underline{t}(60) = .16$), mathematics course content anxiety ($\underline{t}(60) = .71$), and mathematics evaluation anxiety ($\underline{t}(60) = .37$). Consequently, it was concluded that statistics and mathematics course content anxiety and statistics and mathematics evaluation anxiety remained stable over the time interval considered.

In summary, at the aggregate level students scored comparably for statistics and mathematics course content anxiety. The students possessed higher evaluation anxiety toward statistics than toward mathematics.

Individual Differences

As observed with the previous analyses, at the aggregated level students generally responded in a consistent manner with regard to statistics anxiety and mathematics anxiety. It appeared that they were equally anxious or not anxious, as the case may be, about statistics or mathematics. However, the correspondence was not perfect, suggesting that for some individual students there may be differences in anxiety toward statistics and mathematics.

To address this issue, a subsample of students was interviewed. The purpose of these interviews was to compare the reasons students gave as to why they responded the way they did to selected pairs of statistics and mathematics items. The responses to the visual analogue scale were used. In contrast to the 5-point Likert scale, the visual analogue scale enabled a greater range of responses. Therefore it was anticipated that this scale would facilitate discussion of similarities and differences between responses to statistics and mathematics items.

The initial plan was to identify and, subsequently, interview students who exhibited low statistics and high mathematics anxiety, high statistics and low mathematics anxiety, and comparable statistics and mathematics anxieties. The strategy to be used was:

(a) identify students who scored

  (i) less than or equal to the 25th percentile for statistics anxiety and greater than or equal to the 75th percentile for mathematics anxiety,

  (ii) less than or equal to the 25th percentile for mathematics anxiety and greater than or equal to the 75th percentile for statistics anxiety,

  (iii) less than or equal to the 25th percentile for both statistics and mathematics anxiety, and

  (iv) greater than or equal to the 75th percentile for both statistics and mathematics anxiety; and

(b) select four students from each cell.

It was not possible to execute this selection strategy. The reasons for this are provided below followed by a description of the sample of 21 students who were ultimately interviewed.

First, the interview sample was a volunteer sample. As part of the first data collection, the students were asked if they were willing to be interviewed. Of the 92 students in the full sample, 50 students agreed to be interviewed. The distribution of these students, according to the initial percentile identification criteria, is summarized in Panel A of Table 16. Students who scored greater than the 25th percentile and less than the 75th percentile for statistics and mathematics anxiety were classified as exhibiting moderate anxiety. As shown in Panel A, the distribution did not correspond to that expected using the first and third quartile points. That is, the majority of the students in the volunteer sample scored comparably, either low, moderate, or high, for statistics and mathematics anxiety.

It was decided to contact 33 students from this distribution as shown in Panel B of Table 16. Of these, 14 agreed to be interviewed, as shown in Panel C. The reasons for nonresponse included telephone calls not returned (n = 9), unable to contact by telephone (n = 6), and withdrawal of agreement to be interviewed due to time pressures of assignments and exams (n = 4).

It was then decided to augment the sample of 14 students with students with some degree of difference between their mean statistics anxiety score and mean

Table 16

Selection of Students to be Interviewed

Panel A: Classification of Students Who Agreed to be Interviewed

		Statistics Anxiety			
		Low	Moderate	High	Total
Mathematics Anxiety	Low	11	2	--	13
	Moderate	2	20	2	24
	High	--	3	10	13
	Total	13	25	12	50

Panel B: Students Contacted to be Interviewed Based on Percentiles

		Statistics Anxiety			
		Low	Moderate	High	Total
Mathematics Anxiety	Low	11	2	--	13
	Moderate	2	6	2	10
	High	--	3	7	10
	Total	13	11	9	33

Panel C: Students Interviewed Based on Percentiles

		Statistics Anxiety			
		Low	Moderate	High	Total
Mathematics Anxiety	Low	--	1	--	1
	Moderate	--	5	1	6
	High	--	1	6	7
	Total	0	7	7	14

mathematics anxiety score. Given the interviews were conducted soon after the first data collection and prior to the factor analyses, the mean total statistics anxiety and mathematics anxiety scores were used. The standard errors of measurement for the full scale scores were 7.56 for statistics anxiety and 7.65 for mathematics anxiety. The students who were selected had difference scores greater than |10|, or approximately 1.3 times the standard errors of measurement. It was felt that differences of this magnitude would lead to identifiable differentiation between the reasons provided for higher statistics or mathematics anxiety. Seven students were identified using this rule; all agreed to be interviewed. The distribution of difference scores for these seven students and the 14 students identified using percentiles is presented in Table 17.

Organization of the Interview Information

To facilitate the presentation and discussion of the information obtained from the interview sample, an attempt was made to categorize the members of the sample. At this point, the students' statistics and mathematics course content and evaluation anxiety scores were available. Consequently, these scores were used. These scores

Table 17

Distribution of Mean Statistics and Mathematics Anxiety Scores, and Difference Scores of Interview Participants

Student	Mean Statistics Anxiety	Mean Mathematics Anxiety	Difference
1	33.96	89.83	-55.87
2	18.46	33.92	-15.46
3	52.46	65.25	-12.79
4	30.58	38.04	- 7.46
5	46.08	52.46	- 6.38
6	19.06	26.13	- 6.17
7	70.67	72.92	- 2.25
8	75.33	76.42	- 1.08
9	72.50	72.58	- 0.08
10	65.17	58.58	6.58
11	40.96	34.17	6.79
12	50.25	43.38	6.88
13	66.00	59.04	6.96
14	78.79	71.79	7.00
15	20.63	13.46	7.17
16	28.63	17.54	11.08
17	47.21	35.46	11.75
18	65.79	46.83	18.96
19	68.21	46.75	21.46
20	54.83	33.13	21.71
21	94.92	54.50	40.42

together with the gender and age of the students interviewed is presented in Table 18.

Agglomerative hierarchical cluster analysis (Norušis, 1993) of the statistics and mathematics anxiety scale scores was used to identify clusters of students. This statistical analysis begins by designating each case or individual as a separate cluster. Using the squared Euclidean distance as the measure of similarity between students' scores, the cases are combined into increasingly larger clusters until all of the cases are members of a single cluster (Norušis, 1993, p. 85). An agglomeration coefficient schedule, a dendrogram, and a vertical icicle plot are used to determine the number of clusters and the members in each cluster. Small increases in the agglomeration coefficients indicate that relatively homogeneous clusters are being combined, while large coefficients signify that clusters containing fairly dissimilar members are being merged (Norušis, 1993, p. 91). The agglomeration process is usually stopped when the magnitude of the difference between two successive coefficients is large compared to the difference between coefficients during the previous stages of clustering. The dendrogram and the vertical icicle plot displays illustrate the clusters being formed at each successive stage of the hierarchical process.

Table 18

Gender, Age, Subtest Scores, and Difference Between Subtest Scores of Interview Participants

			Course Content Anxiety			Evaluation Anxiety		
Stu.	Gen.	Age	Stats	Math	Diff	Stats	Math	Diff
1	F	49	17.00	90.76	-73.76	67.88	87.57	-19.70
2	F	26	4.63	18.71	-14.08	46.13	70.86	-24.73
3	F	45	48.38	62.53	-14.15	60.63	71.86	-11.23
4	M	28	14.13	22.71	- 8.58	63.50	75.29	-11.79
5	M	32	38.25	43.65	- 5.40	61.75	73.86	-12.11
6	M	30	12.50	20.18	- 7.68	34.88	40.57	- 5.70
7	F	33	63.06	65.71	- 2.64	85.88	90.43	- 4.55
8	M	35	64.25	67.76	- 3.51	97.50	97.43	0.07
9	F	24	67.69	68.59	- 0.90	82.13	82.29	- 0.16
10	F	44	55.44	49.82	5.61	84.63	79.86	4.77
11	F	31	30.63	23.82	6.80	61.63	59.29	2.34
12	F	21	29.38	23.88	5.49	92.00	90.71	1.29
13	M	33	63.31	55.88	7.43	71.38	66.71	4.66
14	F	39	72.06	63.76	8.30	92.25	91.29	0.96
15	F	24	7.19	3.35	3.83	47.50	38.00	9.50
16	F	28	13.44	3.88	9.56	59.00	50.71	8.29
17	F	38	43.13	28.06	15.07	55.06	53.43	1.95
18	F	35	57.56	37.76	19.80	82.25	68.86	13.39
19	F	35	55.56	32.35	23.21	93.50	81.71	11.79
20	F	24	49.44	22.94	26.50	65.63	57.86	7.77
21	M	36	94.44	46.18	48.26	95.88	74.71	21.16

The agglomeration schedule and the diagrams resulting from the student interview data did not yield a clean indication of the number of clusters which best described the data (see Appendix M). A considerable amount of fluctuation was noted between the differences in the successive pairs of agglomeration coefficients. Therefore, a clear point at which to discontinue the agglomeration process could not be determined. Consequently, the use of cluster analysis to classify the interview students was abandoned.

A logical clustering strategy was then employed. Line graphs were created for each of the 21 students interviewed. One line represented the course content anxiety scores for statistics and mathematics, while the second line represented the evaluation anxiety scores for each subject area. An example is presented in Figure 7. The researcher and seven colleagues, one male and three female graduate students, and one female and two male professors, each examined the 21 line graphs independently to determine what clusters or groupings (if any) existed. The criterion used to guide the sorting decisions was to classify the line graphs based on similarities and differences in the scale scores between statistics and mathematics.

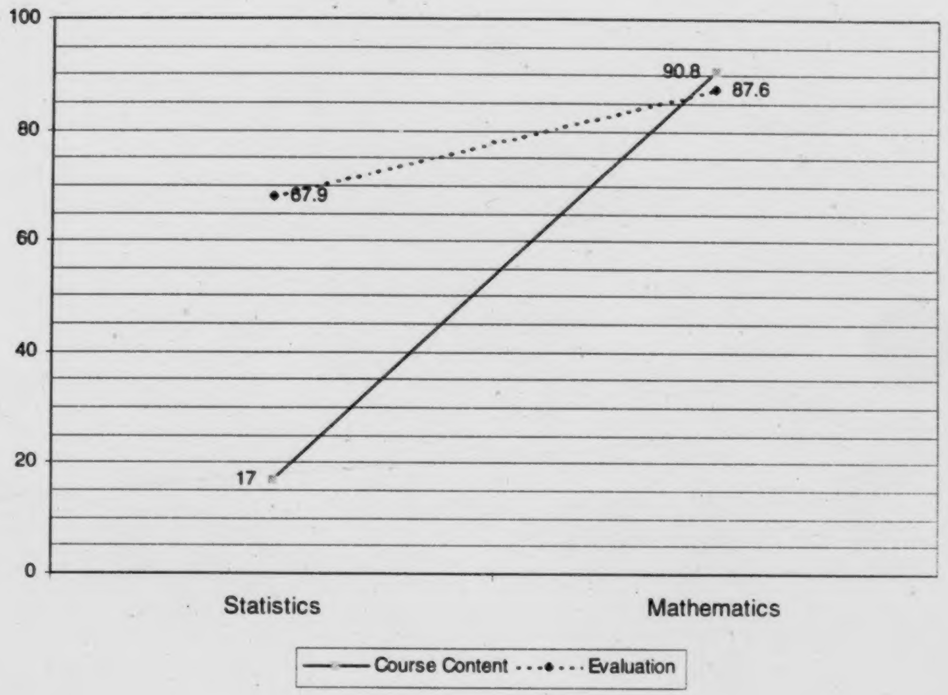


Figure 7. Comparison of Scale Scores Between Subject Areas for Student #1.

The degree of agreement among the eight judges was low, as shown in Appendix N. The only point of total agreement among the judges was that student 1 was an outlier and consequently represented a cluster apart from the other 20 students.

The failure of the statistical cluster analysis and the lack of consensus among the judges highlighted the fact that substantial individual variation existed among the students who were interviewed with regard to their course content and evaluation anxiety for statistics and mathematics (see Table 18). Consequently, the intent to group the students according to statistics and mathematics anxiety scale scores was abandoned.

Explanations for Discrepant Statistics and Mathematics Anxiety

During the interviews, the students were asked to discuss their responses to some of the items on the statistics visual analogue scale and responses to the corresponding mathematics items. Two types of item responses were addressed: (a) where the student responded differently to a statistics anxiety item compared to the parallel mathematics anxiety item and (b) where the student responded comparably to corresponding statistics and mathematics anxiety items. Responses to a pair of statistics and mathematics anxiety items were identified as different when a discrepancy of at least |20| points was observed. Discrepancies less than this were considered to be the same. The standard deviations of the statistics and mathematics anxiety items, provided in Appendix O, were extremely large. The value of |20| represented two-thirds of the mean of the item standard deviations. It was concluded that this value would identify item discrepancies sufficiently large to allow the students to provide different reasons for the discrepancies, should the reasons differ.

Reported in Table 19 are the discrepant pairs of items for each of the students interviewed. The first page of Table 19 presents the discrepant course content anxiety items, while the second page presents the evaluation anxiety items. A total of only 44 (8.79%) discrepant item pairs were found. Items for which no discrepancies were found have not been included (2, 9-11, 14, 19, and 21). The number of discrepant item pairs varied from zero (students 5 and 9) to four (students 3, 19, and 20). In terms of the discrepant items, of the 15 students with two or more discrepancies, seven were more anxious about statistics, five were more anxious about mathematics, and three

Table 19

Discrepant Responses Between Statistics and Mathematics Items

Stu.	S1	M1	S4	M4	S5	M5	S7	M7	S8	M8	S13	M13	S16	M16	S20	M20	S22	M22	S23	M23
1	1	99					16	101												
2	3	35																		
3							26	45							23	70				
4					12	61	17	37												
5																				
6									3	34										
7	75	55																		
8	16	62							33	63										
9																				
10											53	33								
11																				
12																				
13													44	69			67	47		
14																				
15							23	4												
16											36	6								
17	54	20									55	19	39	3						
18									89	49	71	3	77	3						
19			94	6															6	96
20											13	50							75	27
21	79	5													94	71				
n	6		1		1		4		3		5		3		2		1		2	

Note. S and M represent Statistics and Mathematics, respectively. Table 19 is continued on next page.

Table 19 - Continued

Discrepant Responses Between Statistics and Mathematics Items

Stu.	S3	M3	S6	M6	S12	M12	S15	M15	S17	M17	S18	M18	S24	M24	Total # items
1															2
2	21	71													2
3	100	70											48	71	4
4															2
5															--
6															1
7															1
8															2
9															--
10									74	50					2
11							60	35							1
12									77	48					1
13															2
14	98	74							53	74					2
15			63	33			39	14							3
16			45	66							93	61			3
17															3
18															3
19	93	5							95	5					4
20	67	13			15	61									4
21															2
n	5		2		1		2		4		1		1		

Note. S and M represent Statistics and Mathematics, respectively.

exhibited no difference.

Turning to the items, the discrepancies between statistics and mathematics anxiety occurred for 10 (62.5%) of the 16 course content items and 7 (87.5%) of the eight evaluation items. The number of times a discrepancy occurred for the course content items varied from one to six; the range for the evaluation items was one to five. The corresponding means and standard deviations were, respectively, 2.80 and 2.29, and 1.75 and 1.60. At least two students had discrepant ratings for seven course content and four evaluation items. Of these seven course content items, the number of students with higher mathematics anxiety was greater than the number of students with higher statistics anxiety on two items, the same on three items, and reversed on two items. In contrast, the number of students with higher statistics anxiety exceeded the number of students with high mathematics anxiety on three of the evaluation items, and was the same on one item. Together, these findings suggest that, within the interview sample, statistics, particularly with reference to evaluation, induced greater anxiety than did mathematics.

The findings of the protocol analysis are presented in two sections. First, the information obtained at the item level, with regard to statistics and mathematics anxiety, will be addressed. This is followed by a presentation of the information obtained in terms of general questions about the students' levels of statistics and mathematics anxiety.

Protocol Analysis - Item Level

The comments made by a subsample of the students with two or more discrepant items is presented here to illustrate the reasons for feeling more anxious about statistics or mathematics. The presentation begins with statistics.

Statistics. Student 18 responded discrepantly to three course content items (8, 13, and 16). She attributed her high statistics anxiety scores on these items to the fact that she was currently taking a statistics course. She said, "I'm not doing a math course." "It's not pertinent to the plan that I've plotted for myself, whereas statistics really figures into it." When asked whether she would be equally anxious if she was taking a mathematics course now she said, "I still think the statistics anxiety would be higher, but I'm not sure why." Student 18 explained that another reason for her increased anxiety was the awareness of the need to do well in the course. "I really need to know this stuff...it has major repercussions for me if I don't do well (e.g., admission to graduate school)... So I think that also increases the anxiety - the (high) stakes."

Student 17 also exhibited discrepant anxiety to three course content anxiety items (1, 13, and 16). She believed the higher anxiety was a result of a bad previous experience in a research methods course. "I think it's because I took a nursing research course which was the course from hell." "She was a wonderful instructor but... couldn't bring the material down to our level." Student 17 also observed that her increased statistics anxiety was probably related to her discovery that requirements of the course were not what she expected.

> I thought o.k., you know I've got a lot of courses this term. Nursing courses are a lot of work so I thought o.k. stats would be less work. You keep up with it; you get a midterm and final (exam), fine. Well no, he (the professor) doesn't believe in finals. Two research projects! You know I don't have time for research projects!

Another student who demonstrated discrepant anxiety to three mathematics situations was student 19. She had discrepancies for one course content item (4) and two evaluation items (3 and 17). This is a foreign student and, at the time of the interview, this was her first term at the university. "So everything is new to me, I'm trying to get used to things... So you can see I'm anxious because everything is new!" With regard to her high level of anxiety for the evaluation items, she said that she has test anxiety. When asked whether she experienced test anxiety regardless of the subject, she responded, "yes, sure!"

Student 21 exhibited two discrepant responses to course content items (1 and 20). He said that his higher anxiety to 'watching a teacher work a statistical equation on the blackboard' was due to his lack of familiarity with statistics. "... in life you have much more exposure to math than to stats... There's math all around you all the time... We're exposed to stats as well, but I don't interpret it because I don't know the lingo, the jargon."

Student 10 displayed discrepant anxiety for one course content item (13) and one evaluation item (17). Asked why she had higher anxiety for the situation of 'walking on campus and thinking about a statistics course' she responded, "Probably because I'm in a stats course and that anxiety is very real to me." She was asked whether she would feel the same level of anxiety if taking a mathematics course now and said, "I probably would... I'm a driven person to get a 9 (course grade) so...". This student was then asked if her anxiety was a result of her desire to achieve a high grade, rather than anxiety toward specific courses. She responded by saying, "that's right, I think you could probably say the same about almost any course except some courses you come with a better background in order to lessen that anxiety that goes with the desire to achieve at a high level."

A student exhibiting discrepant anxiety toward two evaluation items (6 and 18) was student 16. She said that she did not experience general test anxiety. She explained her increased evaluation anxiety by saying, "I think because math I can grasp a bit faster, so an unexpected quiz I think I would do alright on. Whereas with stats I really have to work at it. So I think I would feel quite nonconfident or unconfident or whatever with an unexpected quiz."

Finally, with regard to discrepant statistics anxiety, student 20 displayed a discrepancy for two evaluation items (3 and 12). She is a foreign student and explained that her anxiety was not due to statistics per se, but rather studying statistics in English.

> I studied math in Korean which is my mother tongue. So that's why I feel comfortable. Cause I used to be really good at math and stats, that kind of stuff. But right now I'm studying stats and this is English and this is my first semester. That's why I feel much higher anxiety I guess. Still, if I study stats in

> Korean I don't think ... I don't feel anxiety very much.

Mathematics. Student 3 displayed discrepant anxiety for three mathematics situations, two course content items (7 and 20) and one evaluation item (24). She commented that the difference was due to proximity of her experiences. "I haven't taken a math course since I was in grade 12 and that's maybe 25 years back. My undergrad stats course was a lot more recent, within three or four years." She went on to explain that the previous statistics course was a very good experience. "A good instructor... I got a good grasp of the material and that gave me confidence for future work or taking stats courses." With regard to mathematics, "if you give me a math problem I really wonder if I can do anything, except basic math."

Student 1 demonstrated discrepant anxiety for two course content anxiety items (1 and 7). She explained that her high level of mathematics anxiety is due to her experiences in high school.

> I know it comes from my high school math. I had to do Math20 three times. The first time was because the teacher punished me. I was talking in class and so he gave me these boards to paint, and when I got the boards painted I could come back to class! So I had a

> very strict father and I had to hide the boards painted and ... it still upsets me. And so then I failed that course because I was out of the class for so long. So then I took it by correspondence. And I finished it in July and wrote the exam in August and I flunked that damn exam, because I'd do a question and I'd redo it! And I'd do a question and I'd redo it because I was so anxious about passing. I did half the exam and got 49% and that's without a word of a lie! So I had to do it again!

Consequently, these negative memories have remained with this student and continue to cause her anxiety with regard to mathematics.

Student 2 also possessed discrepant mathematics anxiety, for one course content situation (1) and one evaluation situation (3). She said that she has never enjoyed math and her anxiety is due to past experiences. "I've actually had people (colleagues and teachers) tell me I don't think that way (mathematically) or math doesn't come easy to me... And maybe part of it is just believing that." She further explained that she found the current statistics course enjoyable. "Well statistics, I think the examples are just more relevant or practical, so that we can relate to them... With the math, it's arbitrary and it just doesn't really have any meaning to me."

Another student exhibiting discrepant anxiety for two situations, both course content items (1 and 8) was student 8. He felt that his higher anxiety for these mathematics situation was because he needs to try to verbalize abstract concepts.

> But I think with math there's so much that's put on the board and so much that really doesn't go well into words. Whereas, you know, maybe a little bit more of statistics... I mean I liked the title of the book (statistics textbook) when I heard it, "Tales of Distribution", that's right up my alley. I love narrative stuff. And if I can see the analogy between telling the story about people and telling the story about a set of... a sample or a population, or whatever. You know I think it might be more user-friendly for me.... I mean I like the idea that you can infer things from statistics. And I think I can do that to a certain extent just naturally. But when it comes to like making formulas for it and stuff like that, I don't know, it's a bit intimidating.

Student 4 demonstrated discrepant anxiety for two course content items (5 and 7). He pointed out that his level of anxiety was dependent upon whether the course was advanced or basic. "I guess now when I hear 'math' in university, ... I guess at that time [when he completed the survey] I was probably thinking in terms of like calculus, right?... And stats I guess because at the time I thought you know, it's a basic course."

Finally, student 20 also exhibited discrepant anxiety for two mathematics situations, one course content item (13) and one evaluation item (12). As mentioned in the section which addressed discrepant statistics anxiety, this student recently arrived from Korea. Consequently, she attributed much of her anxiety to her struggle to understand the language.

Protocol Analysis - General Questions

The interview participants frequently reported feeling anxious toward statistics in general, rather than to any specific statistical situation. Four of the female students (10, 15, 16, and 19) interviewed said that one reason for their statistics anxiety being higher than their mathematics anxiety was because they were currently taking a statistics course.

Three of the male students (6, 13, and 21) and six female students (1, 2, 3, 9, 10, and 16) indicated that they were apprehensive about taking statistics courses, in part, because of comments made by other students with regard to the difficulty or the dullness of the subject matter. Student 6 said that he was surprised by the reactions of friends when he told them he was about to take a statistics course.

> I can't really recall anything specific that anybody said. But generally the look on their faces was like I was one of the Christians that had been chosen to face the lions, or something like that! I mean it was sheer, ghost-white terror, you know. And you start to believe it after a while, you really do start to believe it.

Student 21 acknowledged that because he had no prior experience with statistics, "all of my anxiety comes from, I guess, hearsay."

With regard to statistics evaluation anxiety, 10 of the students interviewed, five males (4, 5, 8, 13, and 21) and five females (12, 14, 17, 18, and 19), conceded that they experienced test anxiety in general, not specifically in relation to statistics. These students indicated that they would score fairly high on items assessing evaluation anxiety, regardless of the subject. Student 12 explained, "I just get anxious taking any kind of exam really." "So I think for any exam I would have put it, kind of whatever, at the top (of the scale)."

Four female students (7, 9, 12, and 14) said that they associated statistics with mathematics. Since they did not believe that they were mathematically inclined, this led to feelings of anxiety regarding statistics. Student 9 commented that her anxiety had lessened since the beginning of the course because she now views statistics as being different from mathematics. "To me, math is a lot more very numerical... statistics is a lot more, more based on concepts and almost logic... there are some numerical elements to it, but I see it as more relatable, math is more abstract." In contrast, student 14 said, "I know with me a lot of the stats anxiety comes from my math anxiety. If I would have had a better framework and understanding of math, I really believe that I just wouldn't have been so anxious about it (stats)."

The 21 interview participants were asked whether they believed statistics anxiety and mathematics anxiety were the same or different. Ten of the students, seven females (1, 2, 3, 9, 16, and 20) and three males (6, 13, and 21), considered the two types of anxiety to be different, seven students, four females (7, 10, 14, and 19) and three males (4, 5, and 8), thought that they were the same, and four female students (11, 12, 15, and 17) did not have an opinion as to whether statistics and mathematics anxieties were the same or different.

A general comment made by the students who believed statistics and mathematics anxiety were different was that part of the difference was due to the fact that mathematics was basically just numbers, whereas statistics had a conceptual and interpretive component. Consequently, statistics anxiety was apprehension to more than just the numbers and numeric calculations. Student 16 explained the difference by saying,

> it's sort of like people who can memorize and spit it out again for a multiple choice exam (e.g., mathematics), versus someone who has to write, who can memorize but then has trouble with a long answer exam (e.g., statistics). I think it's the same kind of idea. That there's a bit of anxiety with having to, not just figure it out, but be able to apply it (statistics).

Student 6 reasoned that a difference must exist because he believed that people could have one form of anxiety, but not the other. "This is just the way I see it, is that people who have no math anxiety could probably have a lot of statistics anxiety."

The students who believed that statistics and mathematics anxiety were the same talked about the anxiety being due to lack of familiarity with both statistics and mathematics. Student 4 explained as follows:

> Personally, my anxiety is sort of one and the same. Like anxiety to me is anxiety. Cause I mean it's part of a course I'm taking, and when I'm taking a math course or a science course... I think I would react the same way if I was taking a biology course and I didn't understand what was going on.

Considerable variation occurred with regard to the length of time between the Time 1 data collections and the interviews. The number of days ranged from two to 73 days; the mean number of days was 27.62 with a standard deviation of 21.74. The variability in time was due to factors such as repeated attempts to contact some of the students and accommodating the students' schedules. The majority of the students (61.9%) were interviewed within 35 days of completing the Time 1 survey.

A frequent comment made by the students was that their level of statistics anxiety had decreased since the beginning of the statistics course. Ten of the students, four males (5, 6, 13, and 21) and seven females (1, 2, 3, 14, 16, and 18) attributed part of this decline in anxiety to their professors' approach to teaching the subject. For these students, the length of time between responding to the Time 1 survey and being interviewed ranged from two to 73 days. Student 14 said she appreciated the fact that her professor seemed to make a real effort to simplify the topics and make them meaningful to the class. For example, during the previous class he explained the concept of t-tests and used the analogy of 'tea for two' to highlight the fact that two groups were involved. Student 14 exclaimed that when the professor made that comment, "it just clicked and I thought nobody will ever have to tell me that again!" "I know that to do a t-test you need two different groups." Consequently, in some cases students began the statistics course feeling extremely anxious and within a period of time felt reasonably comfortable with the subject matter.

In summary, two main "themes" accounting for individual differences in statistics and mathematics anxiety emerge from the interview data. First, students expressed differences due to idiosyncratic events such as unique negative experiences while taking a previous statistics or mathematics course. In particular, negative past experiences were associated with increased current statistics anxiety. The second reason involved the perceived effectiveness of the statistics professor. Additionally, students reported that because they were currently taking a statistics course and not a mathematics course, the feelings of anxiety were more tangible for statistics than for mathematics.

The Relationship Between State and Trait Anxiety and Statistics and Mathematics Anxiety

State and trait anxiety were assessed at both Time One and Time Two. Consequently, the association between state and trait anxiety with statistics and mathematics anxiety could be compared at each occasion, and the stability of state and trait anxiety over time could be examined.

Time 1

One student failed to respond to an item on the state scale, while another student did not respond to an item on the trait scale. In the case of respondents omitting one or two items, Spielberger (1983, p. 12) recommends imputing the mean of the remaining items for that scale. One student did not respond to any of the STAI at Time 1 and therefore was excluded from the state and trait anxiety analyses. Consequently, state and trait anxiety scores were available for 91 students at Time 1.

The means, standard deviations, internal consistencies (Cronbach's α), and the standard errors of measurement for state and trait anxiety are reported in Table 20. As shown, the internal consistencies are high for state and trait anxiety and the standard errors of measurement are less than 3. Furthermore, the internal consistency coefficients are similar to those described by Spielberger (1983) for his college sample (Cronbach's α for state anxiety - .93 for females and .91 for males; and trait anxiety - .91 for females and .90 for males). The means and standard deviations of state and trait anxiety at Time 1 are slightly lower than those reported by Spielberger (1983). In his college sample, he observed state anxiety means and standard deviations, respectively, of 38.76 and 11.95 for females, and 36.47 and 10.02 for males. The means and standard deviations for trait anxiety were 40.40 and 10.15 for females, and 38.30 and 9.18 for males. The correlation between state and trait anxiety was moderately strong at .63.

The associations between state and trait anxiety, and the statistics and mathematics anxiety scales were weak to moderate in strength. The correlation between statistics course content anxiety and state anxiety, .44, was significantly higher than the correlation between statistics

Table 20

Means, Standard Deviations, Cronbach's ∝ and Standard Error of Measurement for State and Trait Anxiety, Time One and Time Two

Anxiety	M	N	Cronbach's ∝	SEM	$r_{state.trait}$
	Time One				
State	33.79 (9.53)	91	.92	2.69	.66
Trait	35.38 (8.02)	91	.91	2.41	
	Time Two				
State	35.87 (11.85)	61	.95	2.65	.78
Trait	36.57 (9.24)	61	.93	2.44	

Correlations Between State and Trait Anxiety and Statistics and Mathematics Anxiety Scales

	Time One		Time Two	
	State	Trait	State	Trait
Statistics Course Content	.44	.29	.43	.42
Statistics Evaluation	.43	.38	.50	.47
Mathematics Course Content	.39	.32	.45	.50
Mathematics Evaluation	.42	.41	.51	.51

course content anxiety and trait anxiety, .29 ($t(88) = 2.09$, $p < .05$). The remaining correlations between state anxiety and each of the statistics and mathematics anxiety scales did not differ significantly from those found for trait anxiety.

Time 2

Two students did not respond to one item on the trait scale. The mean of the remaining items for that scale was imputed. One student did not respond to any of the STAI at Time 2 and was therefore excluded. Consequently, state and trait anxiety scores were available for 61 students at Time 2. The means, standard deviations, internal consistencies, and the standard errors of measurement for Time 2 state and trait anxiety are reported in Table 20. Similar to Time 1, the internal consistencies are high for the state and trait anxiety scales at Time 2. The standard errors of measurement are less than 3. A relatively strong correlation of .78 was obtained between state and trait anxiety.

The associations between state and trait anxiety, and the statistics and mathematics course content anxiety and evaluation anxiety scales were weak to moderate in strength. Unlike Time 1, the relationships between state anxiety and each of the statistics and mathematics anxiety scales did not differ from those found for trait anxiety.

Stability of State and Trait Anxiety Over Time

A comparison between the levels of state and trait anxiety at Time 1 and Time 2 was made for the subsample of students who were assessed at both times. The means, standard deviations, standard error of measurement, and internal consistency of state and trait anxiety for the subsample at Time 1 are presented in Table 21.

Test-retest reliability indicated moderate stability for state anxiety and strong stability for trait anxiety from Time 1 to Time 2. The values were .66 for state anxiety and .84 for trait anxiety. Spielberger (1983, p. 31) acknowledges that lower stability measures are expected for state anxiety than for trait anxiety "because a valid measure of state anxiety should reflect the influence of unique situational factors that exist at the time of testing" (1983, p. 31). Consequently, he suggests that measures of internal consistency such as Cronbach's α "provide a more meaningful index of the reliability of state anxiety scales than test-retest correlations" (p. 31).

Comparison of the mean difference between Time 1 (see Table 21) and Time 2 (see table 20) revealed no significant

Table 21

Means, Standard Deviations, Cronbach's ∝, Standard Error of Measurement, and Correlation with Time 2 for State and Trait Anxiety for Subsample at Time 1

Scales	M (SD)	Cronbach's ∝	SEM	$r_{\text{Time 1 Time 2}}$
State Anxiety	34.43(10.12)	.93	2.68	.66
Trait Anxiety	36.69 (8.56)	.92	2.42	.84

change ($t(60) = -1.22$, $p = .23$ for state anxiety; and $t(60) = 0.18$, $p = .86$ for trait anxiety. The corresponding dispersions for state anxiety were significantly different ($t(60) = -1.88$, $p < .05$). As discussed previously, this difference was attributed to the outliers identified in the state anxiety scores. The dispersions for trait anxiety were equal ($t(60) = -1.09$).

In summary, the subsample of students who were assessed on both occasions exhibited stability in their levels of state and trait anxiety. Weak to moderate correlations were obtained between state and trait anxiety, and the statistics and mathematics course content anxiety and evaluation anxiety scales. At Time 1, state anxiety was more strongly related to statistics course content anxiety than trait anxiety. The remaining correlations did not differ between state and trait anxiety. State and trait anxiety, like course content anxiety and evaluation anxiety for statistics and mathematics (see pp. 133), remained stable over time.

The Predictors of Statistics Anxiety, Mathematics Anxiety, and Course Achievement

The fifth research question of this study was whether the predictors of statistics anxiety and the predictors of mathematics anxiety differed in nature. The sixth and final research question concerned the prediction of achievement in an introductory statistics course. To address these questions, the students provided information about their gender, age, and their student status: part-time or full-time. As well, they provided background information about their experiences with mathematics during high school, how difficult they felt statistics was, their previous experience studying university-level statistics, mathematics, and research methods courses, their experience with computers, and whether they planned to take additional statistics courses (see Appendix D). Students' achievement was reported by the professor in each of the statistics courses as a grade on a 100 point scale.

A brief description of the variables considered as predictors for statistics and mathematics course content and evaluation anxieties, and as predictors for course achievement, are provided in Table 22. Table 23 provides the results of the analyses used to identify the predictors of the statistics and mathematics anxiety subscales and course achievement. The means and standard deviations for the statistics and mathematics anxiety subscales and students' final grades are reported in the first column. Next, the correlations among each of these variables with each of the background variables are provided. The

Table 22

Independent Variables Used as Predictors of Statistics Course Content and Evaluation Anxiety, Mathematics Course Content and Evaluation Anxiety, and Final Grade in Statistics Course

Variable	Description
1	Statistics Course Content Anxiety (mean of visual analogue items)
2	Mathematics Course Content Anxiety (mean of visual analogue items)
3	Statistics Evaluation Anxiety (mean of visual analogue items)
4	Mathematics Evaluation Anxiety (mean of visual analogue items)
5	Final Grade in Statistics Course (percentage grade)
6	Perceived Level of Anxiety Toward Current Statistics Course (1=Not at all to 5=Very much)
7	Perceived Degree of Mathematics Anxiety During High School (1=Not at all to 5=Very much)
8	Previous University-level Mathematics Course (1=No; 2=Yes, Undergraduate level; 3=Yes, Graduate level)
9	Perceived Difficulty of Statistics Compared to Subjects Other than Mathematics (1=Less Difficult to 6=More Difficult)
10	Age in Years
11	Student Status (1=Full-time; 2=Part-time)
12	State Anxiety (mean scale score)
13	Trait Anxiety (mean scale score)
14	Gender (1=Female; 2=Male)
15	Number of Years Since Last Math Course
16	Unpleasant Memories of Studying Mathematics in High School (1=Yes; 2=No)
17	Perceived Degree of Success in High School Mathematics (1=Below Average; 2=Average; 3=Above Average)
18	Perceived Mathematical Ability Today (1=Below Average; 2=Average; 3=Above Average)
19	Perceived Difficulty of Statistics Compared to Mathematics (1=Less Difficult to 6=More Difficult)
20	Previous University-level Statistics Course (1=No; 2=Yes, Undergraduate level; 3=Yes, Graduate level)
21	Previous University-level Research Methods Course (1=No; 2=Yes, Undergraduate level; 3=Yes, Graduate level)
22	Previous Experience Using Computers (1=Yes; 2=No)
23	Plan to Take Other Statistics Courses (1=Yes; 2=No)

Table 23

Correlations of Statistics and Mathematics Anxiety Scales, and Final Grade with Background Variables ($\underline{n}$ = 76)

	Mean	1	2	3	4	6	7	8	9	10	11	12	13
Stats CC	31.57(24.99)	---	---	---	---	.723	.346	$-.382^3$	$.489^1$	-.035	-.107	$.379^2$	.309
Math CC	30.49(23.80)	.846	---	---	---	.547	$.528^1$	$-.463^2$	.309	.024	-.043	$.328^3$	.300
Stats Evl	57.28(25.07)	.823	.773	---	---	.711	.416	$-.459^3$	$.588^1$	$-.192^4$	-.242	.383	$.401^2$
Math Evl	53.98(24.81)	.711	.812	.939	---	.604	$.491^2$	$-.454^1$	$.478^5$	$-.207^4$	-.232	.377	$.405^3$
Grade	83.33 (7.35)	$-.343^1$	-.338	-.215	-.176	-.290	-.191	.201	-.128	$-.245^2$	$.165^3$	-.143	-.128

	14	15	16	17	18	19	20	21	22	23	R_1^2	R_2^2	R_3^2	R_4^2	R_5^2
1	-.120	.112	-.310	-.280	-.404	.360	-.154	-.124	.118	.117	.263	.348	.380	---	---
2	-.150	.171	-.376	-.348	-.374	.128	-.071	-.190	.105	.067	.253	.377	.427	---	---
3	-.254	.008	-.307	-.246	-.448	.332	-.044	-.065	.249	.084	.348	.427	.485	.520	---
4	-.230	-.024	-.316	-.270	-.433	.198	-.016	-.118	.197	.096	.224	.341	.422	.466	.506
5	.064	-.218	.241	.189	.217	-.086	.177	.004	-.021	-.008	.118	.184	.242	---	---

Note. The numbers in superscript denote the order in which variables entered the stepwise regression analyses.

superscript numbers within each of the first five rows depict the order in which variables entered the step-wise regression analyses performed to assist with the identification of significant predictors for statistics course content and evaluation anxieties, mathematics course content and evaluation anxieties, and final grade. The coefficients of determination obtained at each step of the analyses are reported in the lower right portion of the table. Listwise deletion resulted in a sample of 76 students. The issue of whether different variables significantly predict the statistics anxiety subscales and the corresponding mathematics anxiety subscales will be addressed first, followed by the investigation of predictors of final grade.

Comparison of Predictors of Statistics and Mathematics Anxiety

The correlations between each statistics anxiety subscale and the corresponding mathematics anxiety subscale, and between subscales within each subject area were discussed earlier in this chapter (see pp. 130). Thus, they are not discussed further here other than to note the correlation with variable 6. This variable, level of anxiety toward current statistics course, was the most highly correlated of the background variables with statistics and mathematics course content and evaluation anxieties. This finding provides an indication of the validity of the students' statistics and mathematics subscale scores. Therefore, this variable was not included in the subsequent analyses.

The correlations between the remaining background variables and state and trait anxiety (variables 7 to 23 in Table 22) and the statistics and mathematics anxiety subscales were examined. As shown in Table 23, somewhat similar relationships are evident between the background variables and each of the statistics and mathematics subscales. For example, whether a student had previous experience with university-level mathematics (variable 8) was moderately correlated with each of the four statistics and mathematics anxieties. A weak association was found between the number of years since the student last took a mathematics course (variable 14) and each of the anxiety scales. Multiple stepwise regression analyses were used to assist with the identification and comparison of the significant predictors of the statistics and mathematics anxiety subscales.

A comparison of the predictors for statistics and mathematics course content anxiety revealed one unique predictor and two common predictors. For both anxieties, the unique predictor entered first: "perceived difficulty of statistics compared to subjects other than mathematics" (variable 9) accounted for 26.3% of the variation in statistics course content anxiety and "level of mathematics anxiety during high school" (variable 7) accounted for 25.3% of the variation in mathematics course content anxiety. The unique predictor for each of the course content anxieties is likely due to the referent for variable 9 (statistics) and variable 7 (mathematics).

The two common predictors were "state anxiety" and "previous university-level mathematics courses" (variables 12 and 8). These common predictors entered the equations in reverse order; steps 2 and 3 for statistics course content anxiety and steps 3 and 2 for mathematics course content anxiety. The increment in the amount of variation accounted for by variables 12 and 8 was calculated from the R^2 values provided in the lower right panel of Table 23. "State anxiety", followed by "previous university-level mathematics courses" provided increments of 8.5% and 3.2%, respectively, in the predictable variation of statistics course content anxiety. For mathematics course content anxiety, "previous university-level mathematics courses" followed by "state anxiety" produced increments of 12.4% and 5.0%, respectively. Thus, aside from the two unique predictors and the reverse order of the common predictors, the prediction equations for statistics and mathematics course content anxiety are somewhat similar.

A comparison of the predictors for statistics and mathematics evaluation anxiety demonstrated one unique predictor for mathematics and four common predictors. The unique predictor for mathematics was "perceived degree of mathematics anxiety during high school (variable 7) and entered at step 2 of the regression equation. As was the case for the prediction of course content anxiety, this unique predictor is likely due to its referent (mathematics). The common predictors were "perceived difficulty of statistics compared to subjects other than mathematics" (variable 9), "trait anxiety" (variable 13), "previous university-level mathematics courses" (variable 8), and "age" (variable 10). With the exception of "age", all of the common predictors entered the two evaluation anxiety equations in a different order.

For both of the evaluation anxieties, a common, though different, predictor entered first. The first predictor of statistics evaluation anxiety was "perceived difficulty of statistics compared to subjects other than mathematics" (variable 9) which accounted for 34.8% of the variation.

The first predictor of mathematics evaluation anxiety was "previous university-level mathematics courses" (variable 8), accounting for 22.4% of the variation. For statistics evaluation anxiety, the remaining three predictors, in order, were: "trait anxiety" (variable 13), "previous university-level mathematics courses" (variable 8), and "age" (variable 10). These variables provided increments of 7.9%, 5.8%, and 3.5% to the predictable variation in statistics. The remaining four predictors of mathematics evaluation anxiety, in order, were: "perceived degree of mathematics anxiety in high school" (variable 7), "trait anxiety" (variable 13), "age" (variable 10), and "perceived difficulty of statistics compared to subjects other than mathematics" (variable 9). These variables provided increments of 11.7%, 8.1%, 4.4% and 4.0% to the predictable variation in mathematics evaluation anxiety. However, as with the prediction of the course content anxieties, despite the one unique predictor and the different order of the common predictors, the prediction equations for statistics and mathematics evaluation anxiety are somewhat similar. Furthermore, the amount of the variance accounted for by the variables identiifed in the step-wise regression analyses for statistics and mathematics course content anxiety, and statistics and mathematics evaluation anxiety is 38.0%, 42.7%, 52.0%, and 50.6%, respectively. Given the high reliability coefficients of each of these subscales, a substantial amount of the variation has not been accounted for.

Predictors of Achievement

The correlations between the students' final course grade and the statistics and mathematics anxiety subscales and background variables were examined. The coefficients ranged from |.004| to |.343| indicating relatively weak relationships. A multiple stepwise regression analysis was performed to determine whether any of the anxieties and background variables were significant predictors of course achievement. Statistics course content anxiety (variable 1) was the first predictor to enter the regression equation, accounting for 11.8% of the variation in final grade. This was followed by "age" (variable 10) and student status (variable 11). These variables provided increments of 6.6% and 5.8%, respectively, of the predictive variability in final grade. Higher levels of achievement were associated with lower levels of statistics course content anxiety and younger students. A positive relationship existed between achievement and student status in that part-time students demonstrated higher final grades. However, similar to the case of trying to predict course content and evaluation anxieties, for statistics and mathematics, only 24.2% of the variation in final grade has been accounted for.

CHAPTER VI: CONCLUSIONS

This chapter is organized in five sections. In the first section, the research questions and a brief description of the method employed to address these questions are provided. The results are then summarized, followed by identification of the limitations of the study. In the third section, the conclusions derived from the results are presented and compared to the conclusions of previous studies. Implications for practice and for future research are provided, respectively, in the last two sections.

Summary of Research Questions and Method

The purpose of this study was to compare statistics and mathematics anxiety among graduate students in the Social Sciences enrolled in an introductory statistics course. Six specific research questions were addressed. First, the issue of whether different response formats result in different degrees of statistics and mathematics anxiety was examined. Next, similarities and differences between statistics and mathematics anxiety were investigated. Third, statistics and mathematics anxiety were assessed on two occasions to determine if level of anxiety changed over time. The relationship between state and trait anxiety and statistics and mathematics anxiety was then assessed. Next, the predictors of statistics and mathematics anxiety were compared. Finally, the predictors of achievement in a graduate level statistics were examined.

The mathematics anxiety scale used by Plake and Parker (1982) was adopted in the present study. The statistics anxiety scale was constructed by rewriting each of the mathematics anxiety items to depict a parallel situation in the context of a statistics course. Each scale was presented in two response formats: 5-point (1=_not at all_; 2=_a little_; 3=_a fair amount_; 4=_much_; 5= _very much_) Likert and a visual analogue scale with anchors of _not at all anxious_ and _very anxious_. Thus, there were two forms of the Statistics and Mathematics Comparison Scale: SMACS-5PT and SMACS-VAS.

These instruments and the State-Trait Anxiety Inventory (Spielberger, 1983), counterbalanced by order and followed by a background questionnaire, were administered to a sample of 92 students during the second and third weeks of the Fall and Winter teaching terms of the same academic year. Subsequently, during the last week of the term, the anxiety scales were administered, again counterbalanced for order, to 62 students from the first sample. Further, 21 students in the initial sample were individually interviewed within approximately one to four weeks of the first administration to obtain explanations of their responses to the SMACS-VAS.

Three preliminary issues were resolved prior to the main analyses of the students' responses. First, following Spielberger (1983), missing item data, while not frequent, were replaced with the mean item score computed from the remaining items on the anxiety scales for that individual. Second, the student samples at Time 1 and Time 2 were not random samples. These students attended four classes at two universities and volunteered to participate in the study. However, principal components analysis of the total group correlations and the pooled within group correlations yielded nearly identical eigenvalues. Consequently, class membership was disregarded. Lastly, since order of administration was not significant ($p < .05$), the subsamples were collapsed across order.

Summary of Results

Comparison of Response Formats

While the item means differed due to the different metrics of the two scales, there was both a positive linear relationship between item means and moderately strong to strong correlations between response formats for each item. Further, iterative common factor analyses, with squared multiple correlations as the initial communality estimates, followed by an oblique transformation with $\delta = -.1$ yielded a two factor solution for both statistics and mathematics anxiety that were highly similar. The coefficients of congruence exceeded .97 and the root-mean-square deviations were less than .14 for all pairs of corresponding factors across response formats. Taken together, these results indicate that response format was not influential with regard to level of statistics anxiety and mathematics anxiety. Consequently, responses to the visual analogue scale were used for the remaining analyses. This decision was made because it was anticipated that the increased range of values associated with this scale would assist with the investigation of differences between statistics and mathematics anxiety.

Comparison of Statistics Anxiety and Mathematics Anxiety

As indicated earlier, a two factor solution reflected the best simple structure and interpretation for both statistics anxiety and mathematics anxiety. Comparisons between the pattern coefficients for each of the statistics anxiety factors with the corresponding mathematics anxiety factors revealed an almost perfect association: coefficients of congruence exceeded .97 and the root-mean-square deviations were less than .09. The first factor consisted of 16 items which involved anxiety about class related activities associated with studying statistics or mathematics. This factor or scale was labelled Course Content Anxiety. The second factor contained eight items which involved anxiety about activities that related to the assessment of students. Consequently, this scale was labelled Evaluation Anxiety.

Stability of Statistics Anxiety and Mathematics Anxiety

At Time 1 the students' did not differ significantly with regard to their mean course content anxiety scores for statistics and mathematics. In contrast, the mean for statistics evaluation anxiety was significantly higher than the mean for mathematics evaluation anxiety ($p < .05$). Significant differences were not found between the statistics and mathematics mean scale scores at Time 2. Comparisons of the mean differences between Time 1 and Time 2 revealed no significant change for statistics course content anxiety, statistics evaluation anxiety, mathematics course content anxiety, and mathematics evaluation anxiety.

Two main themes emerged from the individual interviews regarding why some students scored differently for statistics anxiety compared to mathematics anxiety. First, students expressed differences due to idiosyncratic events such as negative experiences while taking a previous statistics or mathematics course. In particular, negative past experiences were associated with increased current statistics anxiety. Secondly, the perceived effectiveness of the statistics professor was a common reason provided for reduced statistics anxiety. Additionally, students reported that because they were currently taking a statistics course, the feelings of anxiety were tangible. In contrast, since the students were not currently taking a mathematics course, anxiety toward that subject was not relevant. These students viewed statistics and mathematics anxiety as a situational experience.

The Relationship between State and Trait Anxiety and Statistics and Mathematics Anxiety

The associations between state and trait anxiety and the statistics and mathematics anxiety scales were weak to moderate in strength, at both Time 1 and Time 2. The relationships between state anxiety and each of the statistics and mathematics anxiety scales were comparable to those found for trait anxiety with one exception. At Time 1 the correlation between statistics course content anxiety and state anxiety was observed to be significantly higher ($p < .05$) than the corresponding relationship with trait anxiety. Test-retest reliability coefficients indicated moderately strong stability for state and trait anxiety from Time 1 to Time 2.

Comparison of Predictors of Statistics Anxiety and Mathematics Anxiety

Examination of the correlations between the background variables, state and trait anxiety, and the statistics and mathematics anxiety subscales revealed some comparisons. Somewhat similar relationships were observed between the course content and evaluation anxieties for both statistics and mathematics, and the background variables and state and trait anxiety.

Step-wise regression analyses revealed one unique predictor and two common predictors of statistics and mathematics course content anxiety. The unique predictor for statistics was "perceived difficulty of statistics compared to subjects other than mathematics", while the unique predictor of mathematics was "level of mathematics anxiety during high school." Both statistics and mathematics course content anxiety were predicted by "state anxiety" and "previous university-level mathematics courses". Although each equation contained a unique predictor and the order of the common predictors was reversed, the prediction equations for statistics and mathematics course content anxiety were somewhat similar.

The prediction of evaluation anxiety revealed one unique predictor for mathematics and four common predictors for statistics and mathematics. The unique mathematics predictor was "perceived degree of mathematics anxiety during high school." The common predictors for statistics and mathematics evaluation anxiety were "perceived difficulty of statistics compared to subjects other than mathematics", "trait anxiety" and "previous university-level mathematics courses", and "age". Similar to the prediction of the course content anxieties, aside from the one unique predictor and the different order in which the common predictors entered the equation, the prediction equations for statistics and mathematics evaluation anxiety were somewhat alike. In both cases, however, only a moderate amount of variance was accounted for by the predictors.

Predictors of Course Achievement

A multiple stepwise regression analysis revealed that achievement in the current statistics course was predicted by statistics course content anxiety, age, and student status. However, these predictors accounted for only a moderate amount of the variability of course achievement.

Limitations of the Study

The participants in this study were a volunteer sample of students taking introductory graduate level statistics courses in the Departments of Educational Psychology and Nursing. Additionally, the sample was restricted to two large universities in Western Canada. A further limitation was the fact that an attrition rate of 32.6% was observed between the Time 1 and Time 2 data collections. Consequently, caution should be exercised with regard to the generalizability of the results of this study to other groups of students.

Conclusions

In agreement with Streiner and Norman (1992), response format, at least in the form of a 5-point Likert scale and a visual analogue scale, is not a factor to consider when assessing statistics and mathematics anxiety. There appears to be little difference in the natures of statistics anxiety and mathematics anxiety. Both statistics and mathematics anxiety are characterized by two correlated factors. These factors represent course content anxiety and evaluation anxiety. This outcome contrasts with Plake and Parker (1982). Working with a sample of university students, while they reported the same two factors, they indicated the factors were orthogonal, rather than oblique. However, Rounds and Hendel (1980) and Zeidner (1991), working with samples of university students, reported two correlated factors similar in composition and name to those found in the present study. The identification of two, albeit correlated, factors for both statistics and mathematics indicates that statistics anxiety and mathematics anxiety are each comprised of two distinct constructs.

In agreement with Schwarzer and Jerusalem (1992) and Spielberger (1983), for both statistics and mathematics course content and evaluation anxieties remained stable over time. This outcome is contradictory to the findings of Roberts and Saxe (1982) and the observation of a statistics instructor (J. A. Cameron, personal communication, April 29, 1996).

State and trait anxiety correlated differently with course content anxiety and evaluation anxiety. State anxiety, but not trait anxiety, was a significant predictor of statistics and mathematics course content anxiety. In contrast, trait anxiety, but not state anxiety, was a significant predictor of both of the evaluation anxieties. This finding differs from Betz (1978) and Pretorius and Norman (1992) who reported that mathematics and statistics anxieties were trait-like in nature. Evaluation anxiety, but not course content anxiety, performed in a trait-like manner and resembled test anxiety (Spielberger et al., 1980) It appears that course content anxiety is situational while evaluation anxiety is more constant or lasting.

Implications for Practice

Two immediate implications for practice are evident from the results of this study. First, the assessment of course content and evaluation anxieties, for both statistics and mathematics, did not differ according to the response formats being used. Furthermore, a distinct preference of response format was not detected. Consequently, either the visual analogue scale or the Likert scale may be used to assess statistics and mathematics anxiety. The choice of response format may be based on availability or ease of scoring.

Second, although at the aggregate level differences were not found between statistics and mathematics for either course content or evaluation anxiety, some individual differences among students were observed. This finding warrants the assessment of students, with regard to course content and evaluation anxieties, in both subject areas. Furthermore the same items, with the appropriate referent, can be used to assess statistics and mathematics course content anxiety, and statistics and mathematics evaluation anxiety.

A third implication that may be extracted from the results of this study regards the treatment of course content anxiety and evaluation anxiety. Allowances should be made for individual students who demonstrate differences in anxiety between statistics and mathematics. These individual students could be identified by means of screening. Further and perhaps of greater importance, the treatment for statistics and mathematics course content anxiety should reflect the state or situational nature of this anxiety. In contrast, the treatment for statistics and mathematics evaluation anxiety must be tailored to reflect its long lasting nature.

Implications for Future Research

The results of the study indicate four implications for future research. First, the findings need to be replicated with graduate students in other faculties and locations, and with undergraduate students. Replication will expand the generalizability of the finding that for all intents and purposes, course content anxiety and evaluation anxiety appear to be one and the same for statistics and for mathematics.

Second, the finding that the characteristics of course content anxiety and evaluation anxiety differed, for both statistics and mathematics, warrants further investigation. In particular, the finding that course content anxiety appears to be situation specific in nature and evaluation anxiety appears to be an enduring attribute needs to be examined in greater detail. Differences, if any, between evaluation anxiety and test anxiety need to be investigated.

The third implication for future research regards stability, across time, of course content anxiety and evaluation anxiety. Given the contradictory findings between the present study and those reported by Roberts and Saxe (1982), as well as comments by statistics instructors (J. A. Cameron, personal communication, April 29, 1996), the issue of stability across time requires further examination.

Finally, the finding that a considerable amount of variance could not be explained when predicting course content anxieties, evaluation anxieties, and statistics course achievement merits additional investigation. This need could be addressed in the replication studies called for earlier, with consideration given to additional variables that might account for additional variance.

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APPENDIX A: Statistics-Mathematics Comparison Scale Using a Likert Scale - SMACS-5PT

Statistics-Mathematics Comparison Scale - SMACS-5PT

Student Identification # ________________

Each of the statements below refers to classroom or course situations which may cause anxiety for some students. Anxiety is often described as feelings of dread and apprehension without specific cause for the fear (Chaplin, 1985). Feelings of anxiety vary in degree or intensity, depending on the individual and the situation. Anxiety is associated with negative or unpleasant emotions.

Read each statement carefully, then place a check ( ) in the box under the column that describes how much anxiety you currently feel regarding each situation. Your first response is usually the best one.

Note: *The following 24 statements refer to situations in Mathematics.*

How anxious...	Not at all	A little	A fair amount	Much	Very much
1. Watching a teacher work a mathematical equation on the blackboard.	☐	☐	☐	☐	☐
2. Buying a math textbook.	☐	☐	☐	☐	☐
3. Being given a homework assignment of many difficult math problems which is due the next class meeting.	☐	☐	☐	☐	☐
4. Reading and interpreting graphs or charts in a math textbook.	☐	☐	☐	☐	☐
5. Signing up for a course in mathematics.	☐	☐	☐	☐	☐
6. Thinking about an upcoming math test one day before.	☐	☐	☐	☐	☐
7. Listening to another student explain a math formula.	☐	☐	☐	☐	☐
8. Walking into a math class.	☐	☐	☐	☐	☐
9. Solving a mathematical problem.	☐	☐	☐	☐	☐
10. Looking through the pages of a math text.	☐	☐	☐	☐	☐
11. Starting a new chapter in a math book.	☐	☐	☐	☐	☐
12. Taking an examination (quiz) in a math course.	☐	☐	☐	☐	☐
13. Walking on campus and thinking about a math course.	☐	☐	☐	☐	☐

Situations in Mathematics - Cont'd

How anxious...	Not at all	A little	A fair amount	Much	Very much
14. Picking up a math textbook to begin working on a homework assignment.	☐	☐	☐	☐	☐
15. Getting ready to study for a math test.	☐	☐	☐	☐	☐
16. Reading the word "Mathematics".	☐	☐	☐	☐	☐
17. Working on an abstract mathematical problem, such as: If x=outstanding bills, and y=total income, calculate how much money is left for recreational expenditures.	☐	☐	☐	☐	☐
18. Being given an unexpected quiz in a math class.	☐	☐	☐	☐	☐
19. Reading a formula in mathematics.	☐	☐	☐	☐	☐
20. Listening to a lecture in a math class.	☐	☐	☐	☐	☐
21. Waiting to get a math test returned in which you expected to do well.	☐	☐	☐	☐	☐
22. Having to use the tables in the back of a math book.	☐	☐	☐	☐	☐
23. Being told how to interpret mathematical probability statements.	☐	☐	☐	☐	☐
24. Taking an examination (final) in a math course.	☐	☐	☐	☐	☐

Note: *The following 24 statements refer to situations in Statistics.*

How anxious...	Not at all	A little	A fair amount	Much	Very much
1. Watching a teacher work a statistical equation on the blackboard.	☐	☐	☐	☐	☐
2. Buying a statistics textbook.	☐	☐	☐	☐	☐
3. Being given a homework assignment of many difficult statistics problems which is due the next class meeting.	☐	☐	☐	☐	☐
4. Reading and interpreting graphs or charts in a statistcs textbook.	☐	☐	☐	☐	☐
5. Signing up for a course in statistics.	☐	☐	☐	☐	☐
6. Thinking about an upcoming statistics test one day before.	☐	☐	☐	☐	☐
7. Listening to another student explain a statistical formula.	☐	☐	☐	☐	☐
8. Walking into a statistics class.	☐	☐	☐	☐	☐
9. Solving a statistical problem.	☐	☐	☐	☐	☐
10. Looking through the pages of a statistics text.	☐	☐	☐	☐	☐
11. Starting a new chapter in a statistics book.	☐	☐	☐	☐	☐
12. Taking an examination (quiz) in a statistics course.	☐	☐	☐	☐	☐
13. Walking on campus and thinking about a statistics course.	☐	☐	☐	☐	☐
14. Picking up a statistics textbook to begin working on a homework assignment.	☐	☐	☐	☐	☐
15. Getting ready to study for a statistics test.	☐	☐	☐	☐	☐
16. Reading the word "Statistics".	☐	☐	☐	☐	☐
17. Working out an abstract probability problem, such as: If we have a 52-card deck and randomly chose one card, calculate the probability that card will be a heart *or* an ace.	☐	☐	☐	☐	☐

Situations in Statistics - Cont'd

How anxious...	Not at all	A little	A fair amount	Much	Very much
18. Being given an unexpected quiz in a statistics class.	☐	☐	☐	☐	☐
19. Reading a formula in statistics.	☐	☐	☐	☐	☐
20. Listening to a lecture in a statistics class.	☐	☐	☐	☐	☐
21. Waiting to get a statistics test returned in which you expected to do well.	☐	☐	☐	☐	☐
22. Having to use the tables in the back of a statistics book.	☐	☐	☐	☐	☐
23. Being told how to interpret statistical probability statements.	☐	☐	☐	☐	☐
24. Taking an examination (final) in a statistics course.	☐	☐	☐	☐	☐

APPENDIX B: Statistics-Mathematics Comparison Scale Using a Visual Analogue Scale - SMACS-5PT

Statistics-Mathematics Comparison Scale - SMACS-VAS

Student Identification # ____________________

Each of the statements below refer to classroom or course situations which may cause anxiety for students. Anxiety is often described as feelings of dread and apprehension without specific cause for the fear (Chaplin, 1985). Feelings of anxiety vary in degree or intensity, depending on the individual and the situation. Anxiety is associated with negative or unpleasant emotions.

Read each statement and the anchor words carefully. Draw a short vertical line across the long horizontal line under each statement to show how you feel or rate yourself with regard to each situation. Your first response is usually the best one.

The following are examples to demonstrate how to respond to each statement:

Giving a ten minute presentation in front of the class.

not at all anxious very anxious

Meeting friends for coffee.

not at all anxious very anxious

* * *

Note: *The following 24 statements refer to situations in Mathematics.*

1. Watching a teacher work a mathematical equation on the blackboard.

not at all anxious very anxious

2. Buying a math textbook.

not at all anxious very anxious

Situations in Mathematics - Cont'd

3. Being given a homework assignment of many difficult math problems which is due the next class meeting.

not at all anxious very anxious

4. Reading and interpreting graphs or charts in a math textbook.

not at all anxious very anxious

5. Signing up for a course in mathematics.

not at all anxious very anxious

6. Thinking about an upcoming math test one day before.

not at all anxious very anxious

7. Listening to another student explain a math formula.

not at all anxious very anxious

8. Walking into a math class.

not at all anxious very anxious

9. Solving a mathematical problem.

not at all anxious very anxious

Situations in Mathematics - Cont'd

10. Looking through the pages of a math text.

not at all anxious very anxious

11. Starting a new chapter in a math book.

not at all anxious very anxious

12. Taking an examination (quiz) in a math course.

not at all anxious very anxious

13. Walking on campus and thinking about a math course.

not at all anxious very anxious

14. Picking up a math textbook to begin working on a homework assignment.

not at all anxious very anxious

15. Getting ready to study for a math test.

not at all anxious very anxious

16. Reading the word "Mathematics".

not at all anxious very anxious

Situations in Mathematics - Cont'd

17. Working on an abstract mathematical problem, such as: If x=outstanding bills and y=total income, calculate how much money is left for recreational expenditures.

not at all anxious very anxious

18. Being given an unexpected quiz in a math class.

not at all anxious very anxious

19. Reading a formula in mathematics.

not at all anxious very anxious

20. Listening to a lecture in a math class.

not at all anxious very anxious

21. Waiting to get a math test returned in which you expected to do well.

not at all anxious very anxious

22. Having to use the tables in the back of a math book.

not at all anxious very anxious

23. Being told how to interpret mathematical probability statements.

not at all anxious very anxious

24. Taking an examination (final) in a math course.

not at all anxious very anxious

Note: *The following 24 statements refer to situations in Statistics.*

1. Watching a teacher work a statistical equation on the blackboard.

   not at all anxious very anxious

2. Buying a statistics textbook.

   not at all anxious very anxious

3. Being given a homework assignment of many difficult statistics problems which is due the next class meeting.

   not at all anxious very anxious

4. Reading and interpreting graphs or charts in a statistics textbook.

   not at all anxious very anxious

5. Signing up for a course in statistics.

   not at all anxious very anxious

6. Thinking about an upcoming statistics test one day before.

   not at all anxious very anxious

7. Listening to another student explain a statistical formula.

   not at all anxious very anxious

8. Walking into a statistics class.

   not at all anxious very anxious

Situations in Statistics - Cont'd

9. Solving a statistical problem.

not at all anxious very anxious

10. Looking through the pages of a statistics text.

not at all anxious very anxious

11. Starting a new chapter in a statistics book.

not at all anxious very anxious

12. Taking an examination (quiz) in a statistics course.

not at all anxious very anxious

13. Walking on campus and thinking about a statistics course.

not at all anxious very anxious

14. Picking up a statistics textbook to begin working on a homework assignment.

not at all anxious very anxious

15. Getting ready to study for a statistics test.

not at all anxious very anxious

16. Reading the word "Statistics".

not at all anxious very anxious

Situations in Statistics - Cont'd

17. Working out an abstract probability problem such as: If we have a 52-card deck and randomly chose one card, calculate the probability that card will be a heart or an ace.

not at all anxious very anxious

18. Being given an unexpected quiz in a statistics class.

not at all anxious very anxious

19. Reading a formula in statistics.

not at all anxious very anxious

20. Listening to a lecture in a statistics class.

not at all anxious very anxious

21. Waiting to get a statistics test returned in which you expected to do well.

not at all anxious very anxious

22. Having to use the tables in the back of a statistics book.

not at all anxious very anxious

23. Being told how to interpret statistical probability statements.

not at all anxious very anxious

24. Taking an examination (final) in a statistics course.

not at all anxious very anxious

APPENDIX C: State-Trait Anxiety Inventory

State-Trait Anxiety Inventory

Please provide the following information:

Name______________________________ Date _______

Age ______ Gender (Circle) **M** **F**

Directions: A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate number to the right of the statement to indicate how you feel *right* now, that is, *at this moment*. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe you present feelings best.

	NOT AT ALL	SOMEWHAT	MODERATELY SO	VERY MUCH SO
1. I feel calm....................................	1	2	3	4
2. I feel secure..................................	1	2	3	4
3. I am tense.....................................	1	2	3	4
4. I feel strained................................	1	2	3	4
5. I feel at ease................................	1	2	3	4
6. I feel upset...................................	1	2	3	4
7. I am presently worrying over possible misfortunes..	1	2	3	4
8. I feel satisfied...............................	1	2	3	4
9. I feel frightened..............................	1	2	3	4
10. I feel comfortable...........................	1	2	3	4
11. I feel self-confident........................	1	2	3	4
12. I feel nervous................................	1	2	3	4
13. I am jittery..................................	1	2	3	4
14. I feel indecisive............................	1	2	3	4
15. I am relaxed..................................	1	2	3	4
16. I feel content................................	1	2	3	4
17. I am worried..................................	1	2	3	4
18. I feel confused...............................	1	2	3	4
19. I feel steady.................................	1	2	3	4
20. I feel pleasant...............................	1	2	3	4

Directions: A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate number to the right of the statement to indicate you generally feel.

	ALMOST NEVER	SOMETIMES	OFTEN	ALMOST ALWAYS
21. I feel pleasant	1	2	3	4
22. I feel nervous and restless	1	2	3	4
23. I feel satisfied with myself	1	2	3	4
24. I wish I could be as happy as others seem to be	1	2	3	4
25. I feel like a failure	1	2	3	4
26. I feel rested	1	2	3	4
27. I am "calm, cool, and collected"	1	2	3	4
28. I feel that difficulties are piling up so that I cannot overcome them	1	2	3	4
29. I worry too much over something that really doesn't matter	1	2	3	4
30. I am happy	1	2	3	4
31. I have disturbing thoughts	1	2	3	4
32. I lack self-confidence	1	2	3	4
33. I feel secure	1	2	3	4
34. I make decisions easily	1	2	3	4
35. I feel inadequate	1	2	3	4
36. I am content	1	2	3	4
37. Some unimportant thought runs through my mind and bother me	1	2	3	4
38. I take disappointments so keenly that I can't put them out of my mind	1	2	3	4
39. I am a steady person	1	2	3	4
40. I get in a state of tension or turmoil as I think over my recent concerns and interests	1	2	3	4

APPENDIX D: Background Information

Background Information

Student Identification # ____________________

Please circle the letter which corresponds to your response to the following questions.

1. What is your gender?
   (a) Female
   (b) Male

2. What is your date of birth? ____________________

3a. What degree are you currently working toward?

____

3b. Within which faculty will you receive your degree?

____

3c. What is your registration status?

(a) Full-time (3 or more courses per term)
(b) Part-time (less than 3 courses per term)

3d. When did you begin your current program?

____

3e. What is your undergraduate major?

____

4a. What is the highest level of mathematics that you have studied?

(a) General mathematics
(b) Algebra/trigonometry
(c) Calculus
(d) Beyond calculus

4b. How long has it been since you last took a mathematics course?

____

4c. Would you say that you have unpleasant memories of studying mathematics in high school?

(a) Yes (b) No

Please explain briefly.

____

____

4d. How would you rate your degree of success in high school mathematics?

(a) Below average
(b) Average
(c) Above average

4e. How would you rate your perceived degree of math anxiety in high school? How anxious were you?

(a) Not at all
(b) A little
(c) A fair amount
(d) Much
(e) Very much

4f. How would you rate your perceived mathematical ability today?

(a) Below average
(b) Average
(c) Above average

5. How would you rate the level of anxiety you currently feel about taking this statistics course? How anxious are you?

(a) Not at all
(b) A little
(c) A fair amount
(d) Much
(e) Very much

6a. What is the degree to which you perceive statistics as relatively difficult in comparison to mathematics?

(a) Less difficult
(b) No difference in difficulty
(c) Slightly more difficult
(d) Somewhat more difficult
(e) Moderately more difficult
(f) A great deal more difficult

6b. What is the degree to which you perceive statistics as relatively difficult in comparison to academic subjects other than mathematics?

(a) Less difficult
(b) No difference in difficulty
(c) Slightly more difficult
(d) Somewhat more difficult
(e) Moderately more difficult
(f) A great deal more difficult

7. Have you taken a university-level statistics course before?

(a) No
(b) Yes, undergraduate level
(c) Yes, graduate level

8. Have you ever taken a university-level mathematics course?

(a) No
(b) Yes, undergraduate level
(c) Yes, graduate level

9. Have you taken a university-level research methods course?

(a) No
(b) Yes, undergraduate level
(c) Yes, graduate level

10a. Do you have previous experience using computers?

(a) Yes
(b) No

10b. If yes to 10a, what is the nature of your computer experience? Circle all that apply.

(a) Word processing
(b) Spreadsheets
(c) Data analysis
(d) E-mail
(e) Computer games
(f) Other - Specify: ______________________________
(g) Not applicable

10c. Do you feel comfortable using computers?

(a) Yes
(b) No

10d. If you have no previous experience with computers, do you think that computers will be difficult to learn?

(a) Yes
(b) No

11. What final grade do you expect to receive in this statistics course?

____

12a. Do you think you will take other statistics courses after completion of this one?

(a) Yes
(b) No

12b. Why or why not?

____

____

____

____

13. What type of work do you hope to do after completion of your degree? (Please be specific)

____

____

APPENDIX E: Consent Form for Survey and Interview Participation

Consent Form - Survey Participation

I am a fourth year doctoral student in the Educational Psychology department at the University of Alberta. I am investigating students' perceptions of statistics and mathematics. This research is a component of my doctoral dissertation. I am asking graduate students in Nursing, Educational Psychology, and Health Sciences, currently enrolled in a statistics course, to participate in this study. Participation involves completing the enclosed questionnaires which will be used to gather information about your views and concerns with regard to statistics and mathematics courses.

The questionnaires require approximately 30 minutes to complete. Participants will not be identified by name and subsequent analysis of data resulting from the questionnaires will involve group scores rather than individual scores. All information pertaining to individual participants will remain confidential. You may withdraw your consent to participate at any time during the study, without prejudice.

Additionally, I would like your permission to receive your final exam mark and grade in this course so that I can examine the relationship between responses to these questionnaires and course performance. Grades will be identified by student identification numbers only, not by students' names. This information would be held in strict confidentiality.

Your assistance is greatly appreciated. If you are willing to take part in this study please provide the following information and return this form with the completed questionnaire.

Sincerely,

Carolyn Wentzel
403-492-5427

I agree to participate in this study. I understand that I may withdraw my consent to participate at any time. I also understand that my identity will remain anonymous and that all individual information obtained during this research will be held in confidence.

Name: ______________________________
(please print)

Student Identification Number: __________

Signature: ______________________________

Date: ____________________

I give permission for the researcher to receive my final exam mark and grade in this course. I understand that this information will be kept strictly confidential.

Signature: ______________________________

Consent Form - Interview Participation

A second phase of this study involves individual interviews with a sample of students who completed the questionnaires. The purpose of the interviews is to gain further insight into students' perceptions regarding statistics and mathematics. I am also interested in learning about your past experiences with courses in statistics and/or mathematics.

The interviews will be conducted within the next two weeks at students' convenience. The interviews will last approximately 30 minutes and be audiotaped. Participants will not be identified by name during the interview. You may withdraw your consent to participate at any time during the interview without prejudice.

Confidentiality of the audiotape and transcripts will be maintained at all times. The audiotapes and transcripts will be destroyed upon completion of the study.

Your participation in this study is greatly appreciated. If you are willing to be interviewed please provide the information requested at the bottom of this page. If you have any questions or concerns, please feel free to contact me by telephone at the following numbers:

University:	492-5427
Home:	436-7375

Sincerely,

Carolyn Wentzel

I agree to be interviewed in this study. I understand that I may withdraw my consent to participate at any time during the interview. I also understand that my identity will remain anonymous and that all information obtained during the interview will be held in strict confidentiality.

Name: ______________________________
(Please print)

Student Identification Number: ______________________________

Signature: ______________________________

Preferred day/time to be interviewed: ______________________________

Telephone Number: ______________________________

APPENDIX F: Interview Questions

Interview Questions

Part A:

● Several items from the Statistics-Mathematics Anxiety Scale will be selected for further discussion with each interview participant. Selection of items will be based on variation in the subject's responses between situations in a statistics course and comparable situations in a mathematics course. The subject will be asked to provide reasons for the differing levels of anxiety associated with statistics and mathematics.

● Two response formats were used to assess statistics anxiety and mathematics anxiety; did you prefer using the Visual Analogue Scale or the 5-Point Likert Scale? Why?

Part B:

● **1)** Some people feel anxious when confronted with taking a course in statistics. Using the following scale, please rate your level of anxiety with regard to statistics.

Statistics Anxiety:

not at all anxious 1 2 3 4 5 6 7 very anxious

Why did you choose that rating?

Can you explain to me the reasons for your anxiety?

prompts:
- uncomfortable working with numbers.
- past experience with statistics related courses.
- never did well in quantitative courses.
- statistical terminology, symbols, notation (i.e. a "foreign language").
- did friends or acquaintances tell you anything about statistics courses before you began this one? (i.e. it's a really difficult course).
- concerned about using a computer.

Or:
...it appears that statistics anxiety is not an issue for you.

Can you explain why? (i.e. what previous experiences, etc.)
Why do you think that some students are anxious?
Have you noticed that other students in your EdPsy 500 class appear stats anxious? What do you think might be their reasons for feeling anxious?

● **2)** Some people feel anxious when confronted with taking a course in mathematics. Using the scale below, please rate your level of anxiety with regard to mathematics.

Mathematics Anxiety:

not at all anxious 1 2 3 4 5 6 7 very anxious

Why did you choose that rating?

Can you explain to me the reasons for your anxiety?

possible prompts:
- uncomfortable working with numbers.
- past experience with math related courses.
- never did well in quantitative courses.
- mathematical terminology, symbols, notation (i.e. a "foreign language").
- did you enjoy math in high school? Why/Why not.
- did you feel that you were good in math then? Why/Why not.

Or:
...it appears that math anxiety is not an issue for you.

Can you explain why? (i.e. what previous experiences, etc.)
Why do you think that some students are anxious?
Have you noticed that other students in your EdPsy 500 class appear math anxious? What do you think might be their reasons for feeling anxious?

● **3)** Do you think that differences exist between statistics anxiety and mathematics anxiety?
(Based on what you have told me about your perceptions of stats anxiety and math anxiety)

Yes ____ No ____ I don't know ____

Why/why not?

Explanation.

- What words (adjectives) come to mind when you hear the term "Statistics"?

- What words (adjectives) come to mind when you hear the term "Mathematics"?

APPENDIX G: Orthogonal Two-Factor Solutions for Statistics Anxiety Likert and Visual Analogue Scale Data

Orthogonal Two-Factor Solutions for Statistics Anxiety

Likert and Visual Analogue Scale Data

	Likert Scale		Visual Analogue Scale	
Item No.	Factor I	Factor II	Factor I	Factor II
16	.76	.28	.79	.32
13	.75	.27	.81	.33
8	.75	.24	.86	.26
11	.72	.41	.83	.43
10	.72	.35	.77	.40
1	.69	.42	.73	.38
5	.68	.37	.75	.40
20	.67	.43	.82	.39
23	.66	.51	.66	.54
14	.65	.51	.76	.46
22	.63	.48	.64	.57
4	.58	.47	.65	.54
2	.55	.13	.69	.24
7	.53	.40	.76	.46
12	.23	.88	.34	.84
24	.26	.84	.25	.87
6	.40	.83	.40	.85
18	.27	.73	.28	.78
17	.42	.64	.52	.68
15	.51	.63	.52	.72
3	.37	.61	.40	.68
19	.59	.60	.78	.49
9	.56	.59	.69	.58
21	.30	.58	.38	.56

APPENDIX H: Orthogonal Three-Factor Solutions for Statistics Anxiety Likert and Visual Analogue Scale Data

Orthogonal Three-Factor Solutions for Statistics Anxiety

Likert and Visual Analogue Scale Data

	Likert Scale			Visual Analogue Scale		
	Factors			Factors		
	I	II	III	I	II	III
Item No.						
24	.87	.19	.26	.22	.86	.22
12	.84	.31	.16	.33	.84	.19
6	.78	.41	.28	.32	.81	.34
18	.75	.17	.27	.26	.77	.21
3	.57	.33	.28	.28	.62	.40
17	.56	.47	.24	.36	.61	.49
15	.55	.47	.35	.44	.69	.37
21	.55	.29	.22	.35	.55	.21
19	.52	.52	.41	.64	.43	.50
4	.31	.74	.25	.45	.45	.58
22	.34	.69	.34	.37	.45	.73
23	.39	.65	.40	.41	.43	.69
1	.31	.62	.45	.52	.28	.62
11	.31	.59	.50	.74	.39	.42
14	.43	.53	.47	.73	.44	.31
9	.51	.51	.38	.56	.52	.49
7	.34	.43	.38	.65	.41	.43
8	.25	.20	.81	.87	.25	.25
16	.27	.28	.76	.77	.31	.28
13	.27	.29	.75	.82	.33	.24
5	.35	.33	.62	.73	.39	.27
10	.28	.51	.54	.66	.35	.44
20	.36	.50	.51	.61	.28	.66
2	.11	.26	.49	.57	.19	.40

APPENDIX I: Oblique Three-Factor Solutions for the Statistics Anxiety Likert and Visual Analogue Scale Data: Pattern Coefficients

Oblique Three-Factor Solutions for the Statistics Anxiety Likert and Visual Analogue Scale Data: Pattern Coefficients

	Likert Scale			Visual Analogue Scale		
	Factors			Factors		
	I	II	III	I	II	III
Item No.						
4	.87	-.04	-.08	.21	-.27	.49
22	.75	-.07	.06	.03	-.26	.73
23	.66	-.13	.14	.11	-.23	.66
1	.61	-.04	.24	.36	.00	.56
11	.55	-.04	.32	.72	-.11	.17
10	.44	-.02	.42	.62	-.09	.24
14	.43	-.22	.28	.75	-.20	.01
9	.41	-.35	.15	.40	-.33	.30
19	.41	-.36	.18	.53	-.18	.31
20	.40	-.13	.36	.46	.03	.58
7	.35	-.17	.23	.59	-.17	.22
24	-.14	-.99	.05	-.08	-.98	-.03
12	.09	-.93	-.13	.09	-.93	-.10
18	-.14	-.84	.11	.01	-.86	-.03
6	.20	-.77	.00	.01	-.85	.12
3	.16	-.54	.08	.00	-.60	.27
21	.14	-.54	.03	.22	-.53	-.01
17	.39	-.47	-.02	.07	-.53	.37
15	.34	-.44	.12	.22	-.63	.14
8	-.12	-.04	.93	1.04	.09	-.07
16	.01	-.05	.82	.86	-.02	-.01
13	.03	-.05	.80	.95	-.04	-.09
5	.11	-.16	.59	.79	-.15	-.03
2	.15	.08	.50	.56	.09	.27

Factor Correlation Matrix

Likert Scale

	I	II	III
I	1.00		
II	-.68	1.00	
III	.69	-.59	1.00

Visual Analogue Scale

	I	II	III
I	1.00		
II	-.67	1.00	
III	.70	.60	1.00

APPENDIX J: Orthogonal Two-Factor Solutions for the Mathematics Anxiety Likert and Visual Analogue Scale Data

Orthogonal Two-Factor Solutions for the Mathematics Anxiety Likert and Visual Analogue Scale Data

	Likert Scale		Visual Analogue Scale	
	Factors		Factors	
	I	II	I	II
Item No.				
20	.83	.32	.83	.36
1	.80	.36	.68	.37
5	.78	.35	.67	.46
8	.77	.22	.85	.32
14	.77	.46	.76	.47
10	.76	.36	.84	.36
11	.76	.39	.82	.37
19	.76	.49	.73	.49
9	.73	.50	.70	.56
22	.71	.42	.75	.44
23	.71	.43	.72	.51
4	.69	.46	.60	.52
16	.66	.27	.73	.25
13	.65	.37	.75	.29
7	.60	.50	.65	.51
2	.58	.23	.68	.26
17	.50	.50	.53	.55
12	.30	.89	.34	.91
24	.25	.88	.31	.84
18	.31	.74	.32	.82
6	.52	.74	.38	.86
15	.50	.67	.49	.66
21	.34	.60	.27	.59
3	.48	.57	.44	.65

APPENDIX K: Orthogonal Three-Factor Solutions for the Mathematics Anxiety Likert and Visual Analogue Scale Data

Orthogonal Three-Factor Solutions for the Mathematics Anxiety Likert and Visual Analogue Scale Data

	Likert Scale			Visual Analogue Scale		
	Factors			Factors		
	I	II	III	I	II	III
Item No.						
14	.74	.44	.33	.70	.44	.35
23	.72	.37	.31	.60	.46	.45
1	.69	.51	.25	.41	.26	.74
4	.64	.41	.36	.36	.44	.64
15	.62	.21	.57	.40	.63	.35
9	.59	.51	.42	.58	.52	.46
10	.59	.54	.28	.81	.34	.30
7	.59	.35	.41	.66	.51	.21
11	.58	.55	.31	.79	.35	.30
17	.55	.25	.41	.36	.50	.49
22	.53	.52	.34	.57	.38	.56
8	.31	.78	.19	.77	.29	.39
16	.21	.73	.26	.66	.22	.34
5	.42	.70	.31	.59	.43	.36
20	.58	.62	.24	.71	.32	.45
13	.33	.62	.34	.81	.29	.14
19	.55	.58	.42	.64	.46	.41
2	.32	.51	.20	.50	.19	.54
24	.24	.23	.87	.29	.84	.19
12	.36	.20	.84	.31	.90	.24
18	.18	.33	.75	.31	.82	.19
6	.45	.38	.68	.33	.84	.29
3	.25	.48	.57	.27	.59	.49
21	.38	.20	.54	.24	.57	.18

APPENDIX L: Oblique Three-Factor Solutions for the Mathematics Anxiety Likert and Visual Analogue Scale Data: Pattern Coefficients

Oblique Three-Factor Solutions for the Mathematics Anxiety Likert and Visual Analogue Scale Data: Pattern Coefficients

	Likert Scale			Visual Analogue Scale		
	Factors			Factors		
	I	II	III	I	II	III
Item No.						
14	.97	-.05	-.03	.72	.20	.06
23	.96	-.07	-.09	.53	.26	.21
1	.93	-.12	.07	.25	.08	.66
4	.81	.05	.00	.14	.35	.52
20	.76	-.06	.26	.75	.02	.20
10	.76	-.02	.17	.94	.01	-.02
11	.72	.03	.18	.90	.03	-.01
7	.70	.15	-.04	.67	.32	-.11
9	.70	.16	.12	.47	.35	.21
15	.68	.34	-.23	.20	.60	.13
17	.66	.17	-.12	.16	.43	.33
22	.64	.10	.17	.50	.16	.36
19	.63	.19	.22	.60	.24	.15
5	.47	.14	.43	.57	.23	.11
2	.38	.05	.30	.48	-.05	.40
24	-.05	.97	-.01	.00	.94	-.07
18	-.09	.85	.14	.03	.90	-.07
12	.16	.85	-.12	-.02	1.01	-.03
6	.37	.58	.04	.02	.91	.03
3	.10	.58	.28	-.02	.61	.34
21	.33	.45	-.09	.04	.62	.00
8	.35	.06	.59	.87	-.05	.12
16	.16	.21	.59	.76	-.08	.11
13	.32	.24	.39	1.00	-.04	-.20

Factor Correlation Matrix

Likert Scale

	I	II	III
I	1.00		
II	.71	1.00	
III	.53	.29	1.00

Visual Analogue Scale

	I	II	III
I	1.00		
II	.70	1.00	
III	.59	.48	1.00

APPENDIX M: Agglomeration Schedule for the Statistics and Mathematics Scale Scores of the Interview Participants

Agglomeration Schedule for the Statistics and Mathematics Scale Scores of the Interview Participants

Stage	Clusters Combined Cluster 1	Cluster 2	Coefficients	Difference
1	7	9	110.067	--
2	7	14	126.143	16.076
3	7	8	142.332	16.189
4	17	20	190.713	48.381
5	11	17	247.556	56.843
6	10	18	276.571	29.015
7	10	19	325.156	48.585
8	15	16	333.246	8.090
9	3	13	409.324	76.078
10	7	10	423.707	14.383
11	2	4	427.753	4.046
12	3	7	447.022	19.269
13	3	5	464.324	17.302
14	6	15	477.257	12.933
15	2	11	533.015	55.758
16	2	3	663.455	130.455
17	2	6	773.421	109.966
18	2	12	840.786	67.365
19	2	21	1097.740	256.954
20	1	2	2081.124	983.384

APPENDIX N: Logical Cluster Analyses of the Eight Judges

Logical Cluster Analyses of the Eight Judges

	Judges							
Cluster	1	2	3	4	5	6	7	8
1	1	1	1	1	1	1	1	1
2	2,4	2,4	2,3,4,5,6	2,4	2,4	2,3,4,5	2,4,5,11,12, 16	2,3,4,5
3	3,5	3,5,13	--	3,5,6,7	3,5	--	3,7,8,9,10, 13,14,17,18, 19,20,21	6,7,8,9,10, 11,12,13,14, 15,16
4	6	6	--	--	6	--	6,15	--
5	7,8,9, 14	7,8,9, 10,14	7,8,9,12	8,9	7,8,9, 14	7,8,9,10, 13,14	--	--
6	10,18, 19	18,19	10,13,14, 18,19	10,13, 18,20	10,18, 19	17,18,19, 20	--	17,18,19,20, 21
7	11,15, 16	15,16	11,15,16, 17,20	15,16,19	11	6,11,12, 15,16	--	--
8	12	12	--	11,12, 14,17	12	--	--	--
9	13,17, 20	11,17, 20	--	--	13,17, 20	--	--	--
10	21	21	21	21	21	21	--	--
11	--	--	--		15,16	--	--	--

APPENDIX O: Item Means and Standard Deviations for Statistics and Mathematics Anxiety Items

Item Means and Standard Deviations for Statistics and Mathematics Anxiety Items

Item No.	Statistics Mean (SD)	Mathematics Mean (SD)
1	29.64(27.49)	27.22(26.94)
2	24.97(27.55)	21.93(26.34)
3	55.73(31.07)	52.90(27.84)
4	38.75(30.15)	35.97(27.65)
5	32.10(30.33)	34.37(30.21)
6	60.84(28.78)	60.32(29.02)
7	38.49(28.89)	39.61(27.51)
8	26.80(27.17)	29.43(27.79)
9	39.62(29.97)	36.60(29.61)
10	32.01(28.48)	32.57(28.14)
11	30.00(28.29)	27.98(26.38)
12	60.54(27.88)	60.00(29.55)
13	29.00(26.70)	25.66(24.30)
14	32.60(27.53)	31.99(28.22)
15	50.48(30.89)	46.51(31.46)
16	26.35(28.87)	17.89(21.67)
17	44.02(30.90)	31.52(28.51)
18	67.53(26.94)	64.41(30.07)
19	39.16(30.75)	36.18(28.83)
20	28.73(26.63)	28.59(26.33)
21	51.32(31.51)	48.54(30.59)
22	35.64(30.41)	32.70(30.12)
23	37.24(30.52)	38.76(32.12)
24	69.96(26.24)	69.00(26.43)

Note. N = 92.